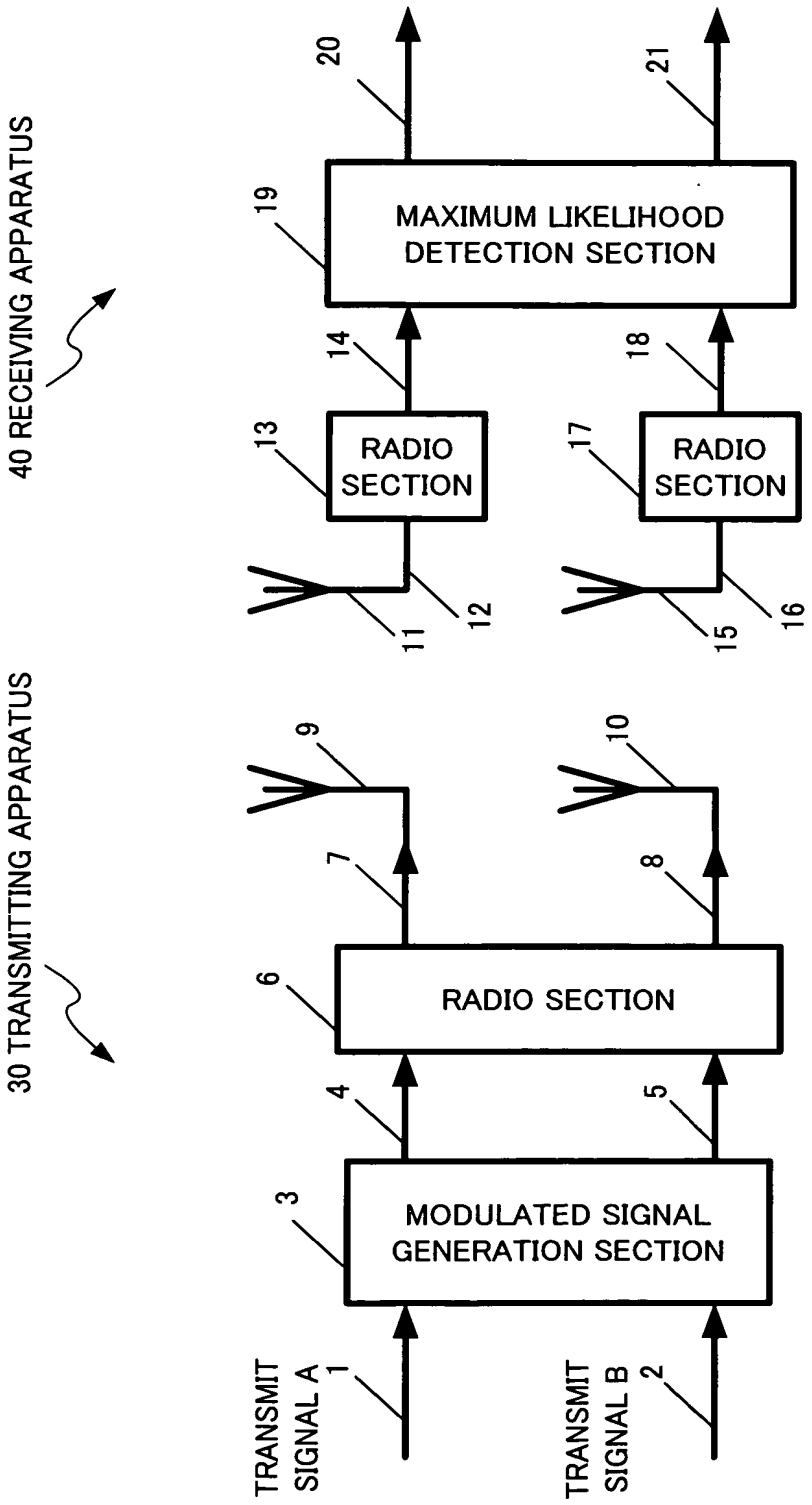


(PRIOR ART)

FIG.1

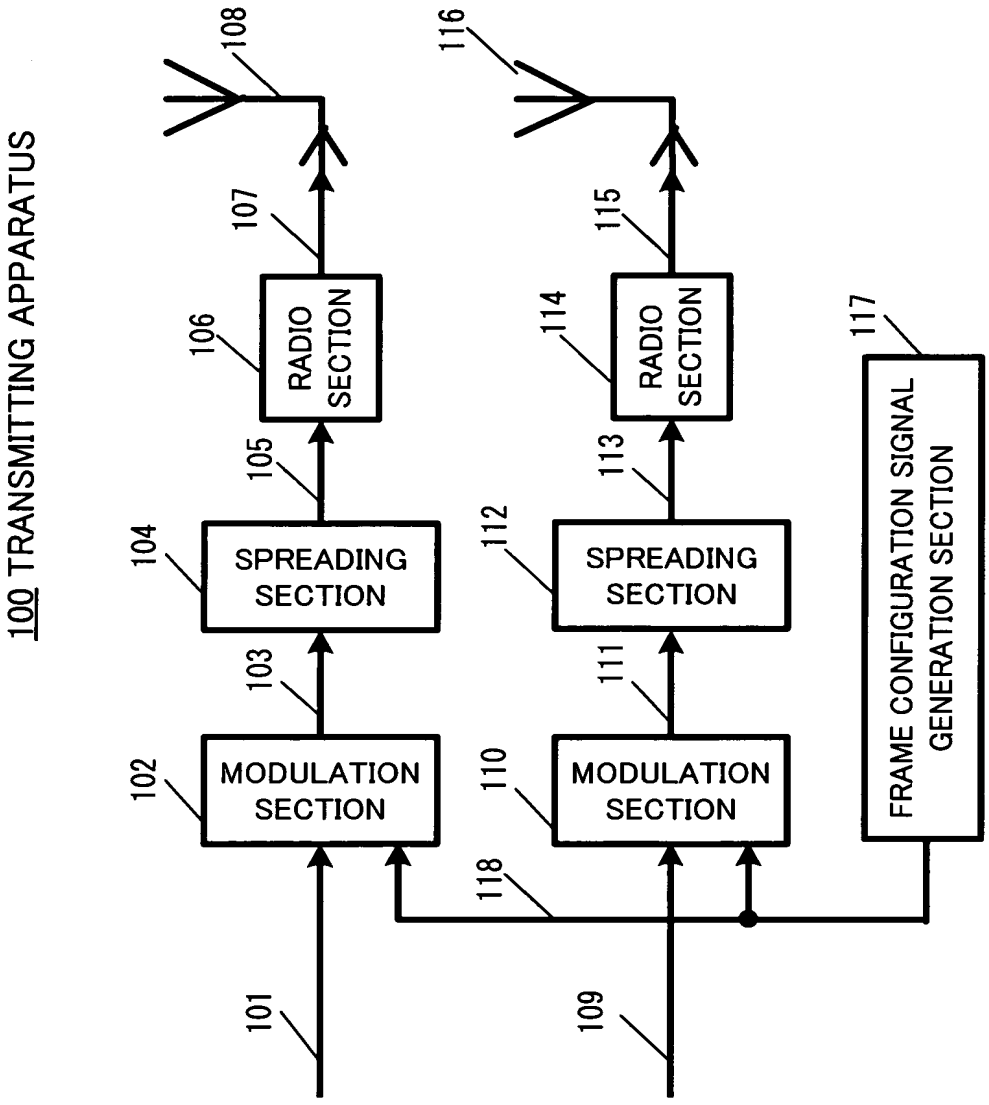

100 TRANSMITTING APPARATUS
101
102
MODULATION SECTION
103
104
SPREADING SECTION
105
106
RADIO SECTION
107
108
109
110
MODULATION SECTION
111
112
SPREADING SECTION
113
114
RADIO SECTION
115
116
117
FRAME CONFIGURATION SIGNAL GENERATION SECTION
118

FIG.2

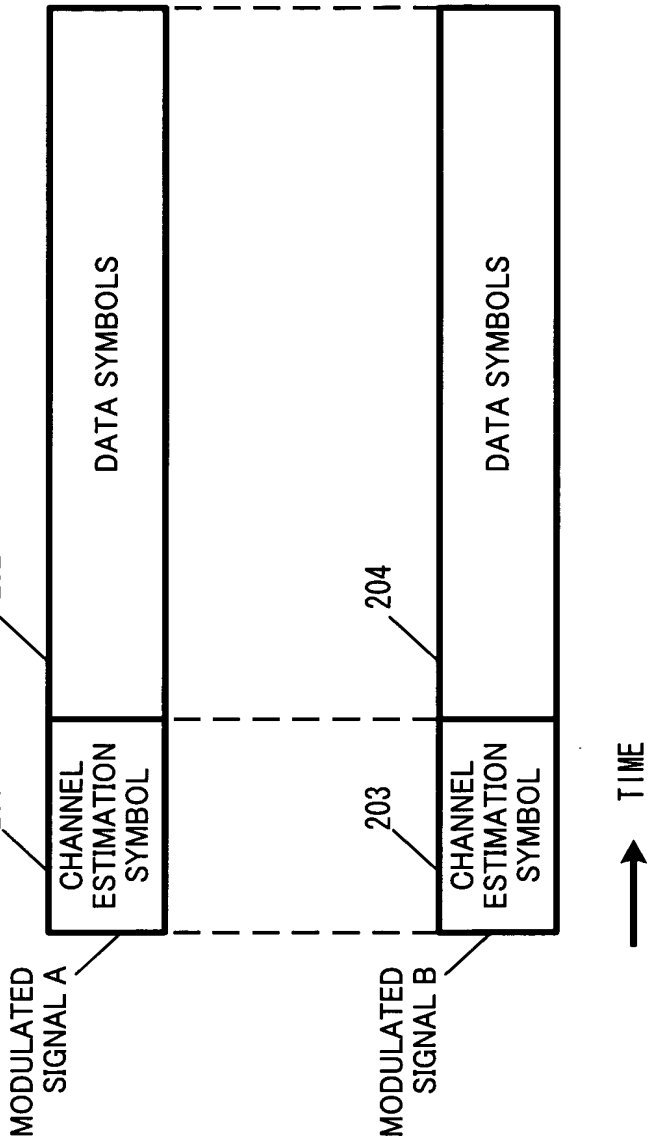

MODULATED SIGNAL A
MODULATED SIGNAL B
CHANNEL ESTIMATION SYMBOL
DATA SYMBOLS
201
202
203
204
TIME

FIG.3

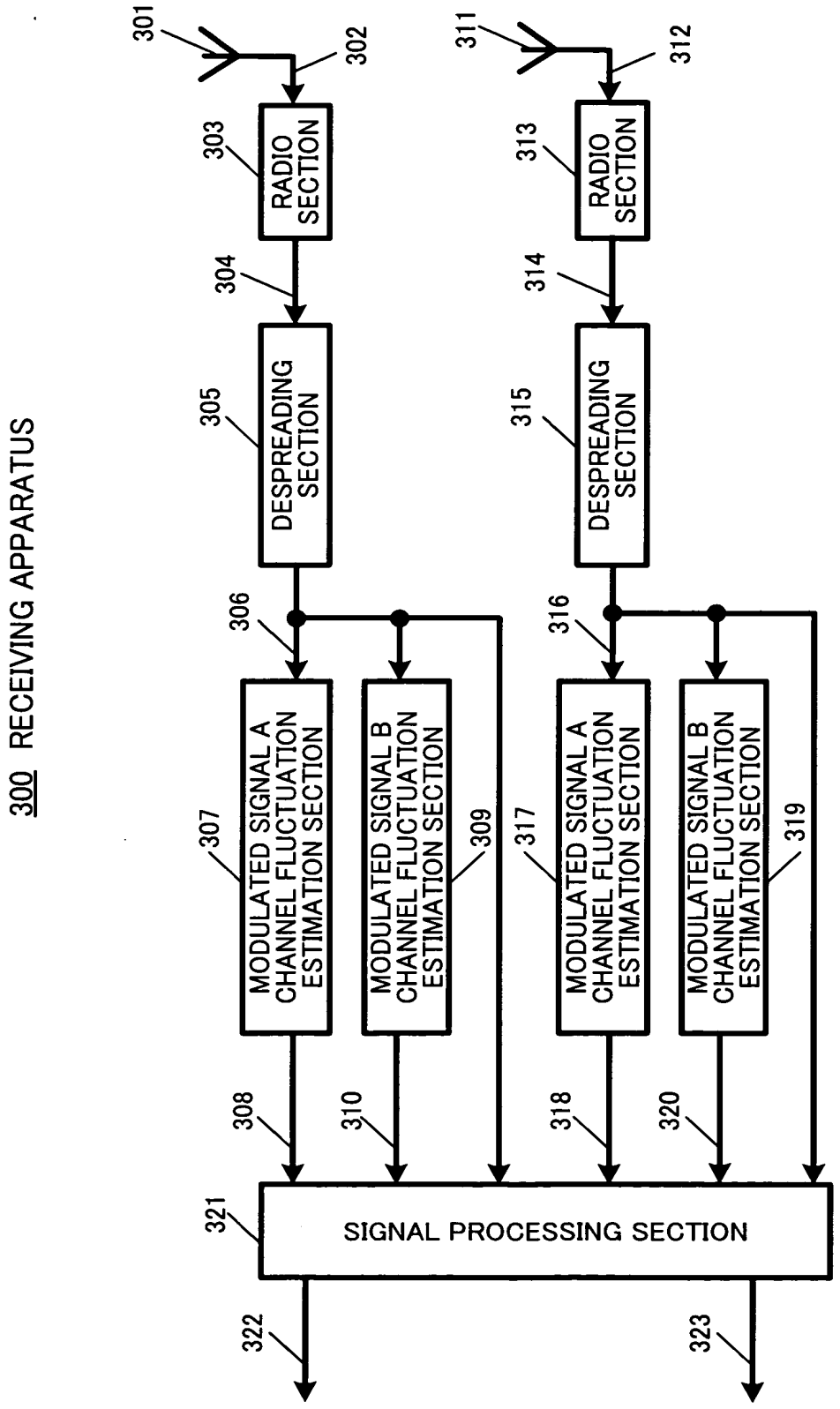

300 RECEIVING APPARATUS
301
302
311
312
303
313
RADIO SECTION
RADIO SECTION
304
314
DESPREADING SECTION
DESPREADING SECTION
305
315
306
316
MODULATED SIGNAL A CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL B CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL A CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL B CHANNEL FLUCTUATION ESTIMATION SECTION
307
309
317
319
308
310
318
320
321
SIGNAL PROCESSING SECTION
322
323

FIG.4

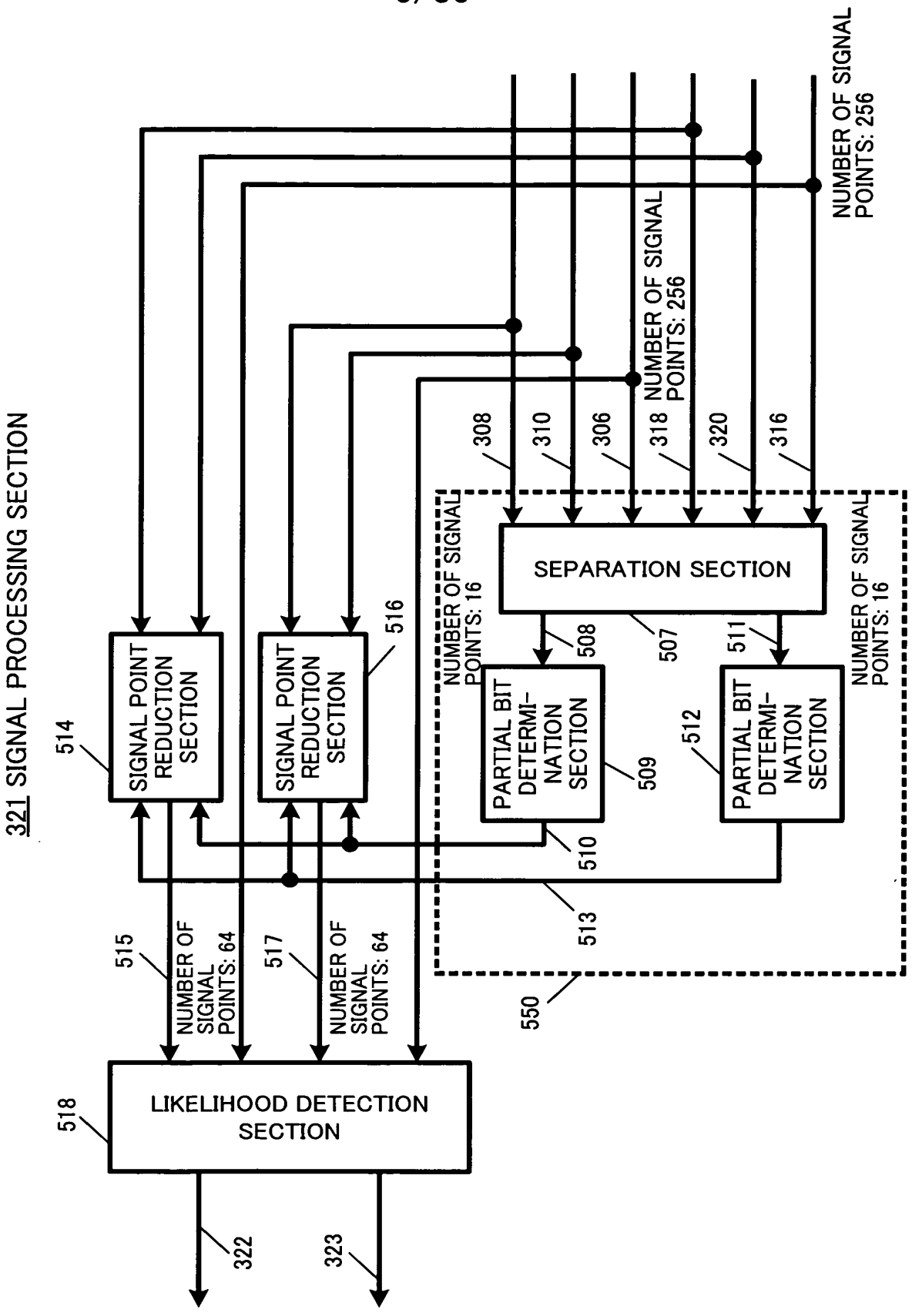

321 SIGNAL PROCESSING SECTION
NUMBER OF SIGNAL POINTS: 256
NUMBER OF SIGNAL POINTS: 256
308
310
306
318
320
316
SEPARATION SECTION
NUMBER OF SIGNAL POINTS: 16
NUMBER OF SIGNAL POINTS: 16
507
508
511
SIGNAL POINT REDUCTION SECTION
514
SIGNAL POINT REDUCTION SECTION
516
PARTIAL BIT DETERMI-NATION SECTION
509
PARTIAL BIT DETERMI-NATION SECTION
512
510
513
515
NUMBER OF SIGNAL POINTS: 64
517
NUMBER OF SIGNAL POINTS: 64
550
LIKELIHOOD DETECTION SECTION
518
322
323

FIG.5

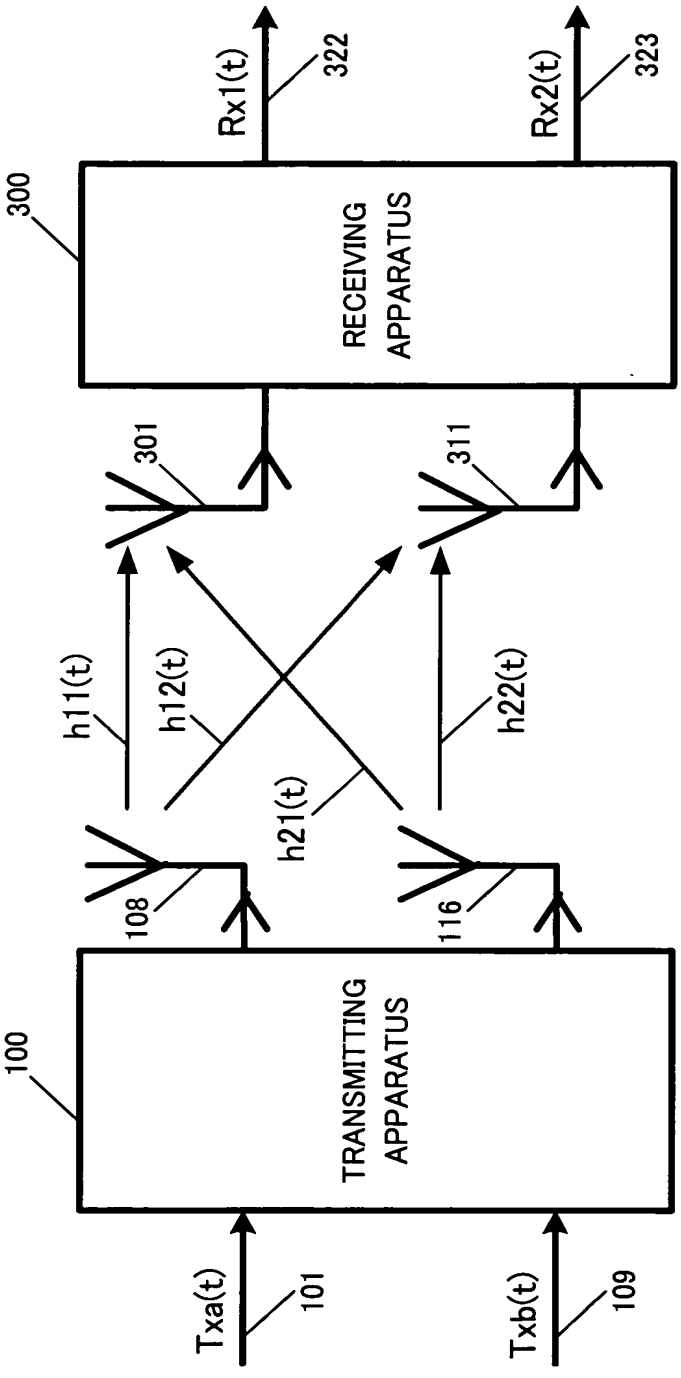

Txa(t)
101
Txb(t)
109
100
TRANSMITTING APPARATUS
108
116
h11(t)
h12(t)
h21(t)
h22(t)
301
311
300
RECEIVING APPARATUS
Rx1(t)
322
Rx2(t)
323

FIG.6

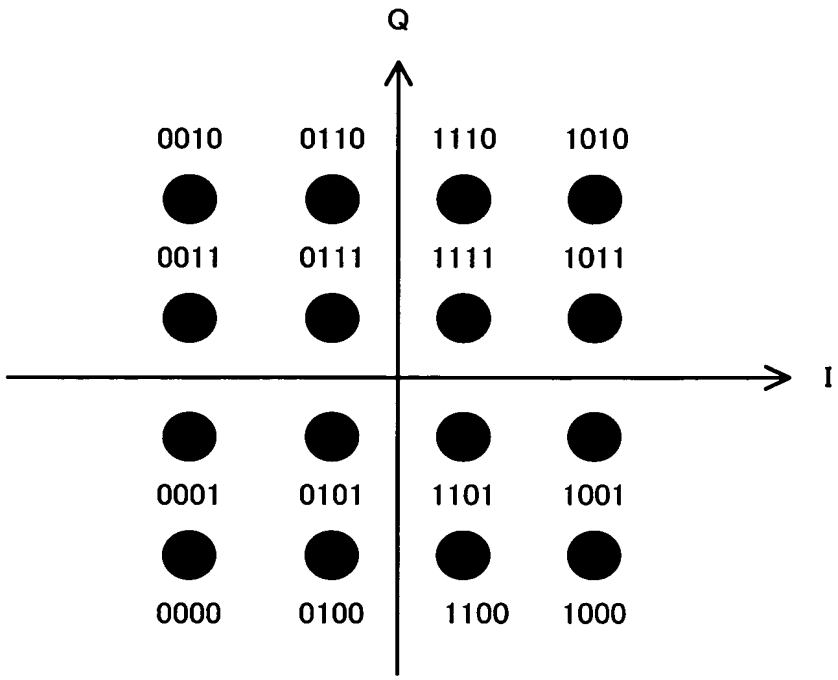

Q
I
0010
0110
1110
1010
0011
0111
1111
1011
0001
0101
1101
1001
0000
0100
1100
1000

FIG.7A

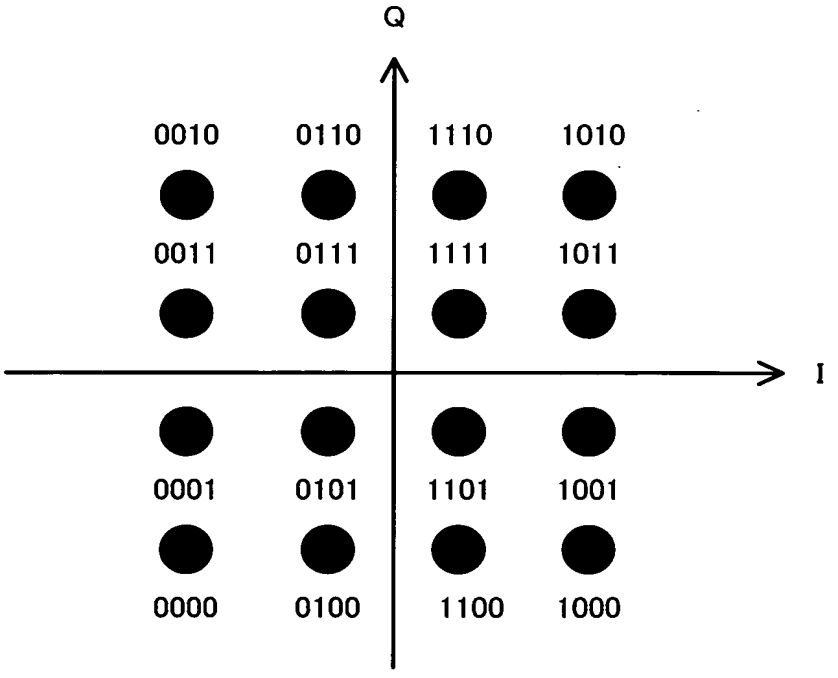

Q
I
0010
0110
1110
1010
0011
0111
1111
1011
0001
0101
1101
1001
0000
0100
1100
1000

FIG.7B

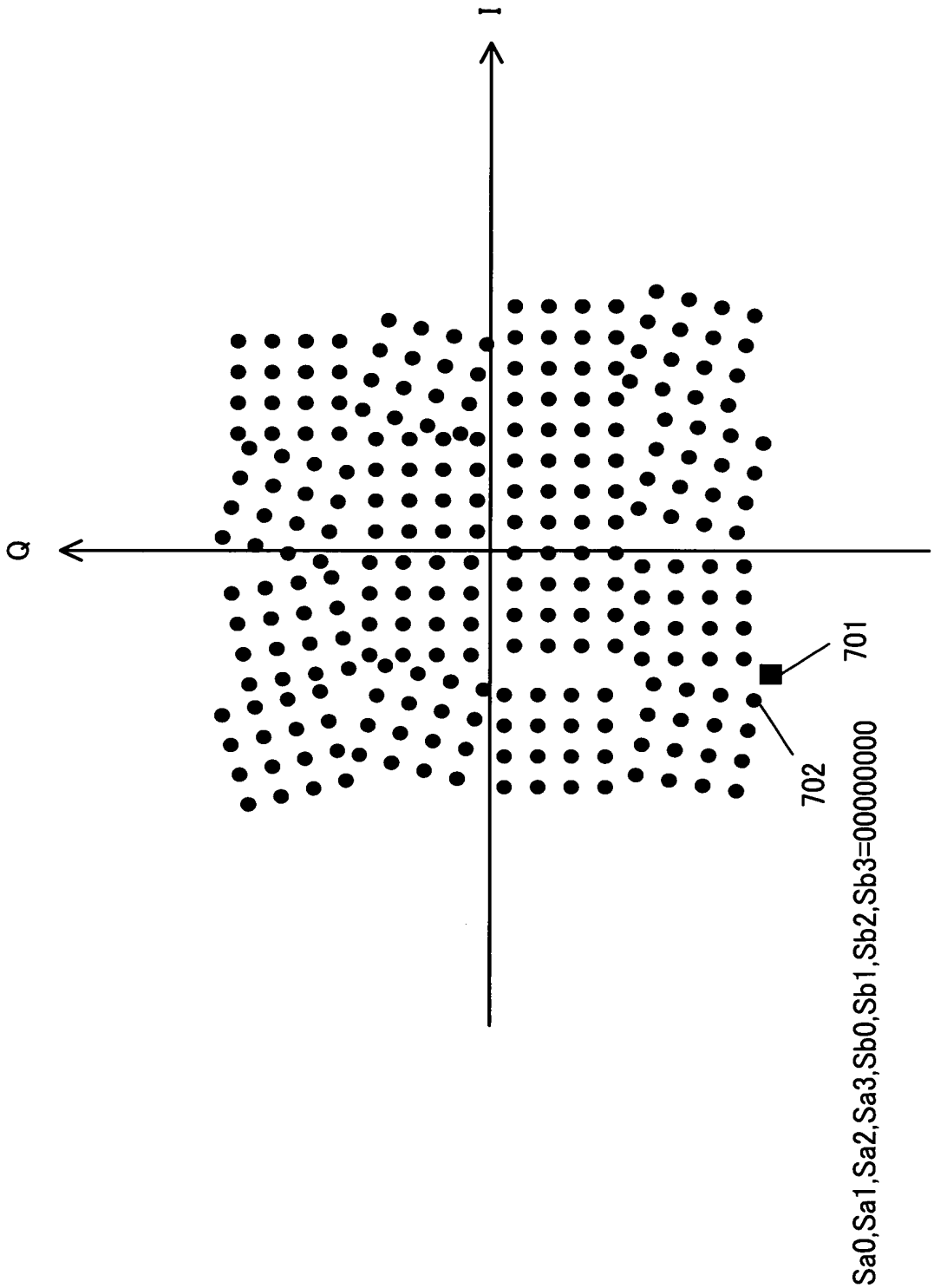


FIG.8

FIG.9A

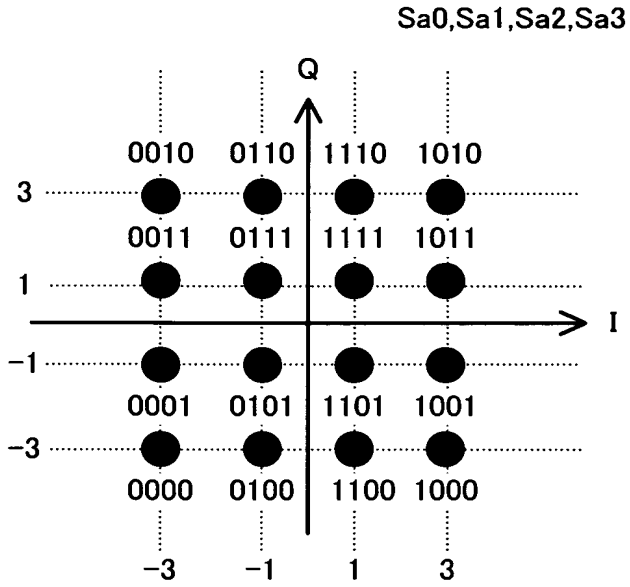
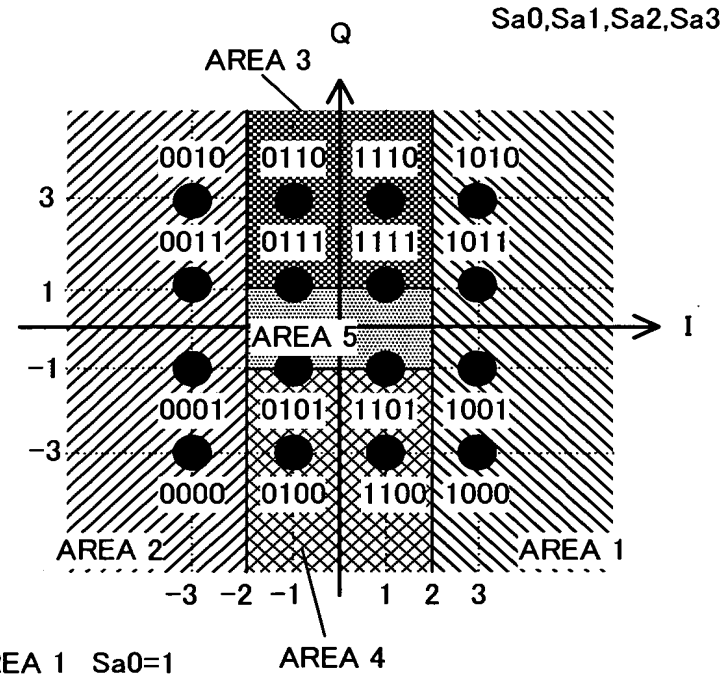


FIG.9B



AREA 1 Sa0=1
AREA 2 Sa0=0
AREA 3 Sa2=1
AREA 4 Sa2=0
AREA 5 Sa3=1

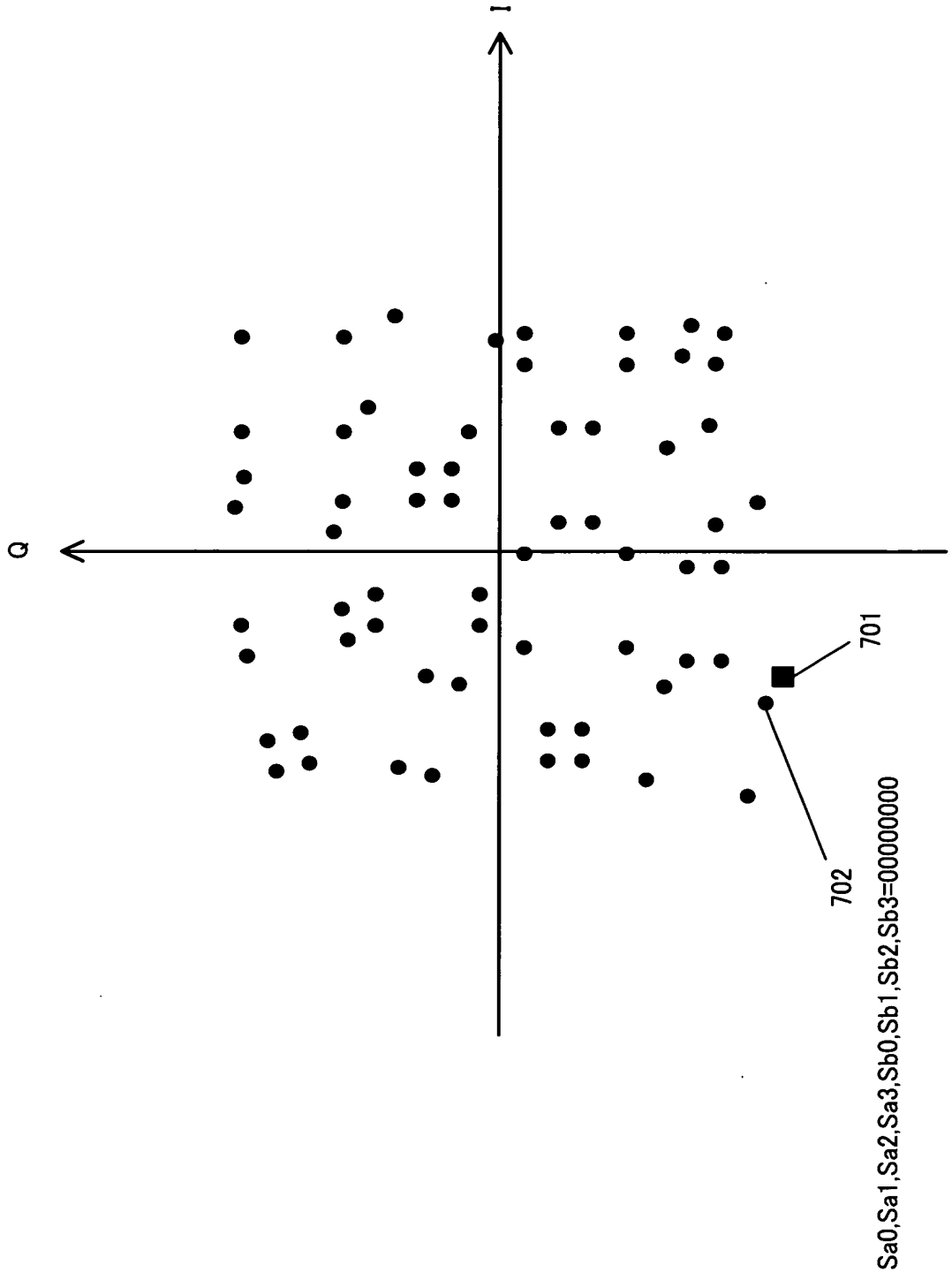


FIG.10

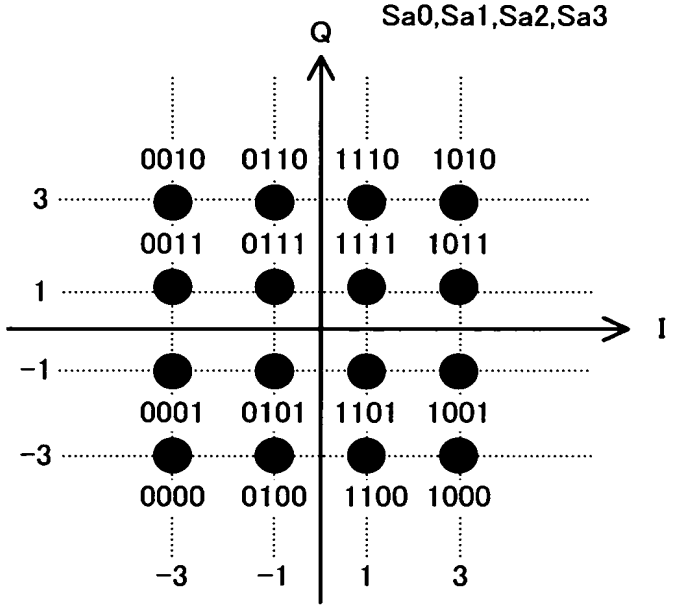
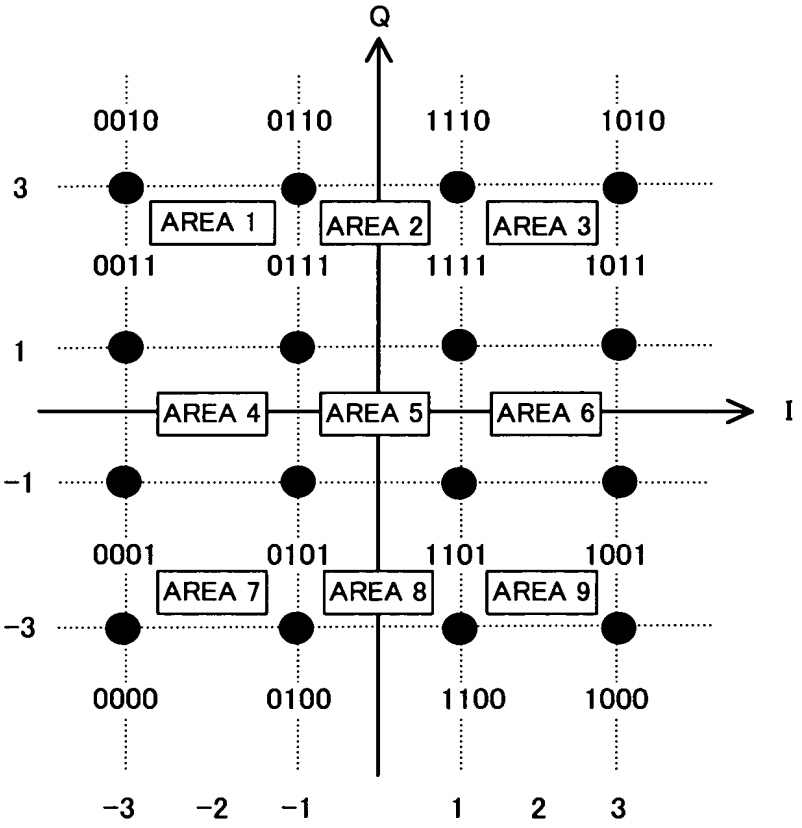


FIG.11A



AREA 1 Sa0=1, Sa2=1
AREA 2 Sa1=1, Sa2=1
AREA 3 Sa0=1, Sa2=1
AREA 4 Sa0=0, Sa3=1
AREA 5 Sa1=1, Sa3=1
AREA 6 Sa0=0, Sa3=1
AREA 7 Sa0=0, Sa2=0
AREA 8 Sa1=1, Sa2=0
AREA 9 Sa0=1, Sa2=0

FIG.11B

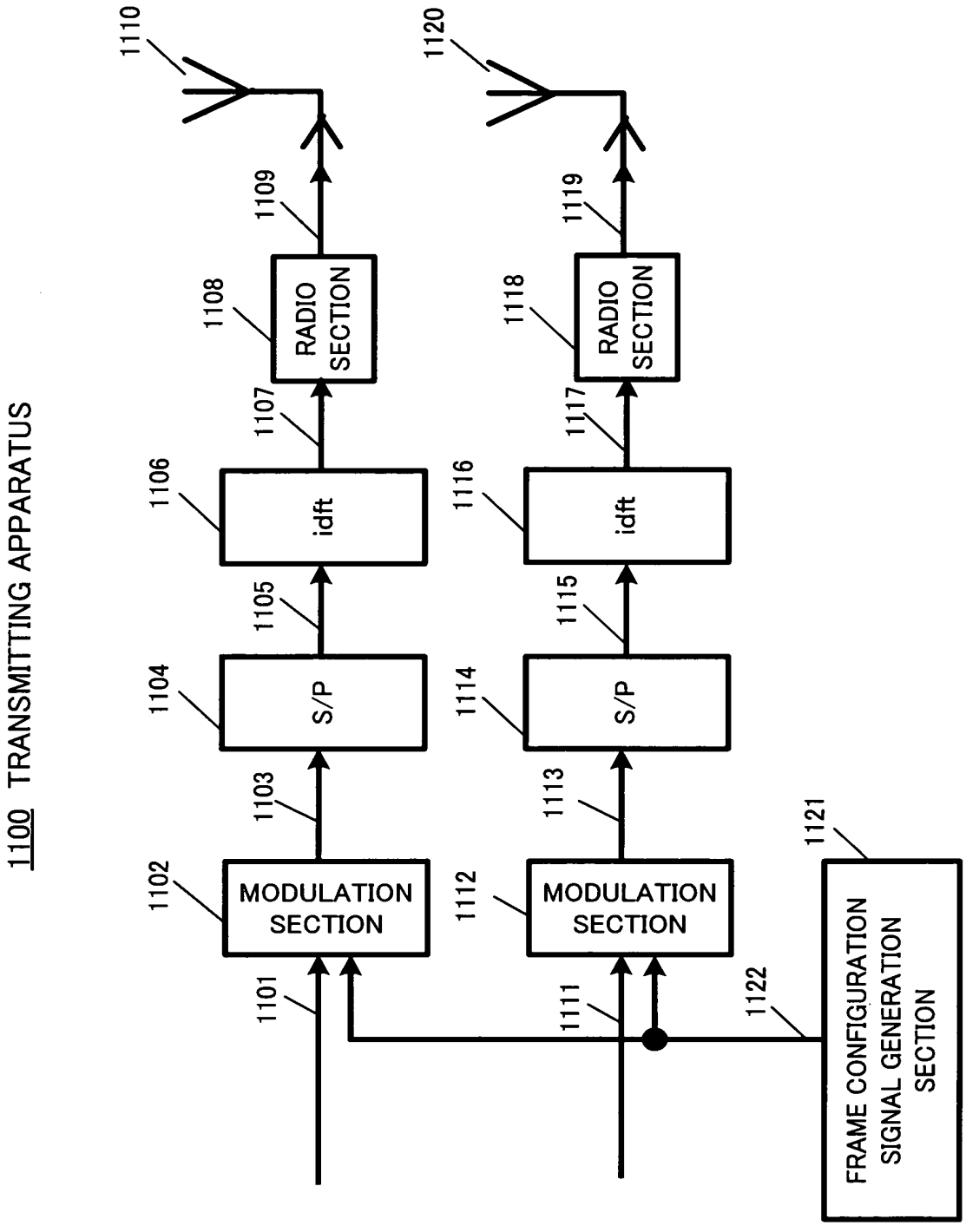

1100 TRANSMITTING APPARATUS
1101
1102
MODULATION SECTION
1103
1104
S/P
1105
1106
idft
1107
1108
RADIO SECTION
1109
1110
1111
1112
MODULATION SECTION
1113
1114
S/P
1115
1116
idft
1117
1118
RADIO SECTION
1119
1120
1121
FRAME CONFIGURATION SIGNAL GENERATION SECTION
1122

FIG.12

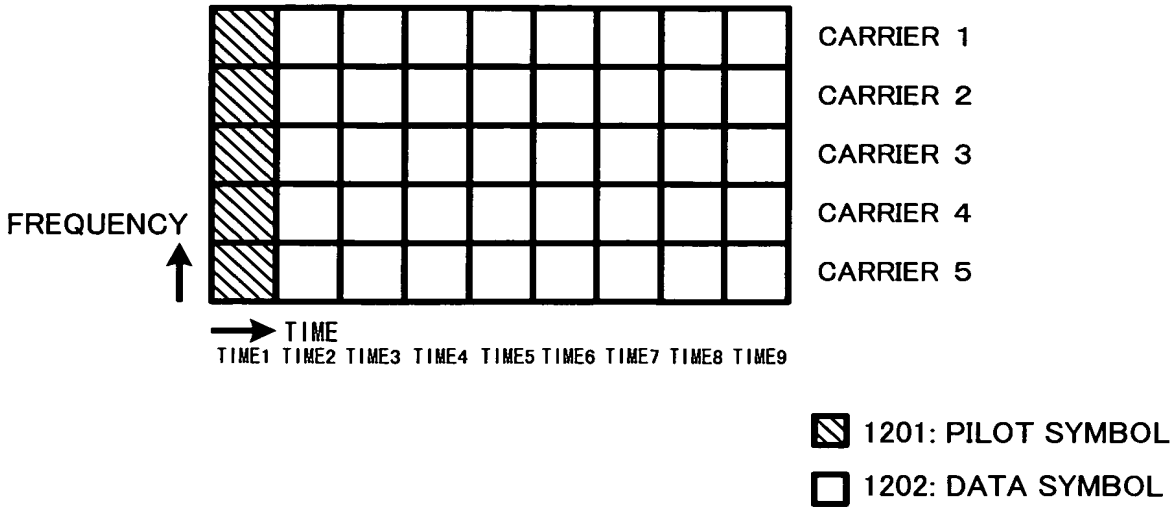


FIG.13A

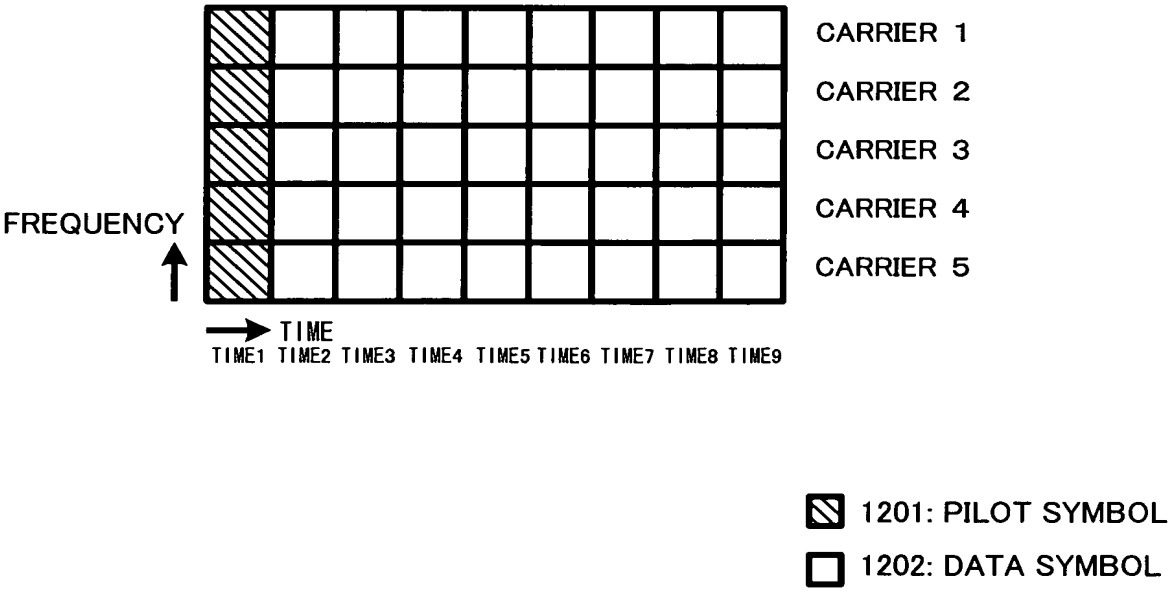


FIG.13B

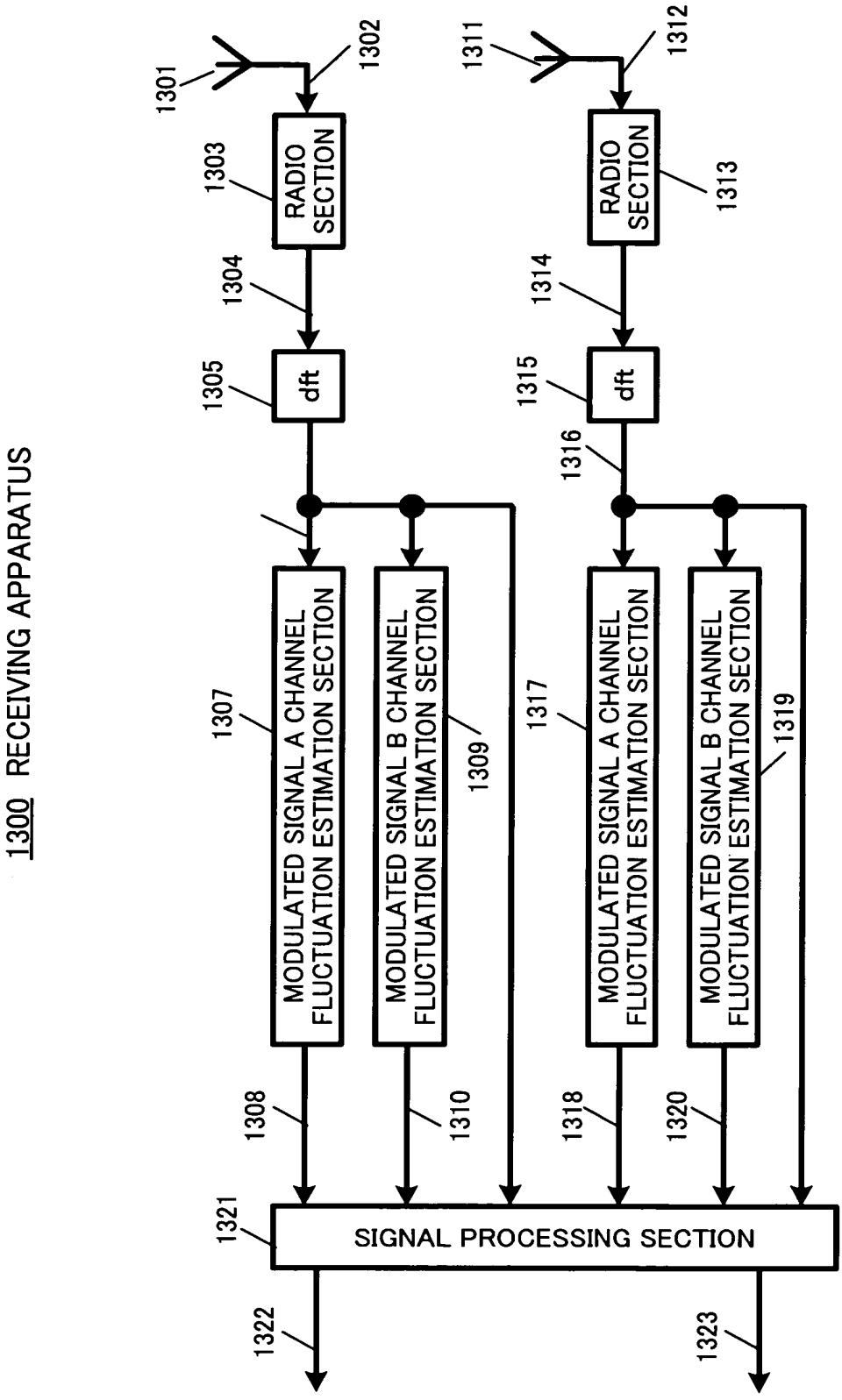

1300 RECEIVING APPARATUS
1301
1302
1303
RADIO SECTION
1304
1305
dft
1307
MODULATED SIGNAL A CHANNEL FLUCTUATION ESTIMATION SECTION
1309
MODULATED SIGNAL B CHANNEL FLUCTUATION ESTIMATION SECTION
1308
1310
1311
1312
1313
RADIO SECTION
1314
1315
dft
1316
1317
MODULATED SIGNAL A CHANNEL FLUCTUATION ESTIMATION SECTION
1319
MODULATED SIGNAL B CHANNEL FLUCTUATION ESTIMATION SECTION
1318
1320
1321
SIGNAL PROCESSING SECTION
1322
1323

FIG.14

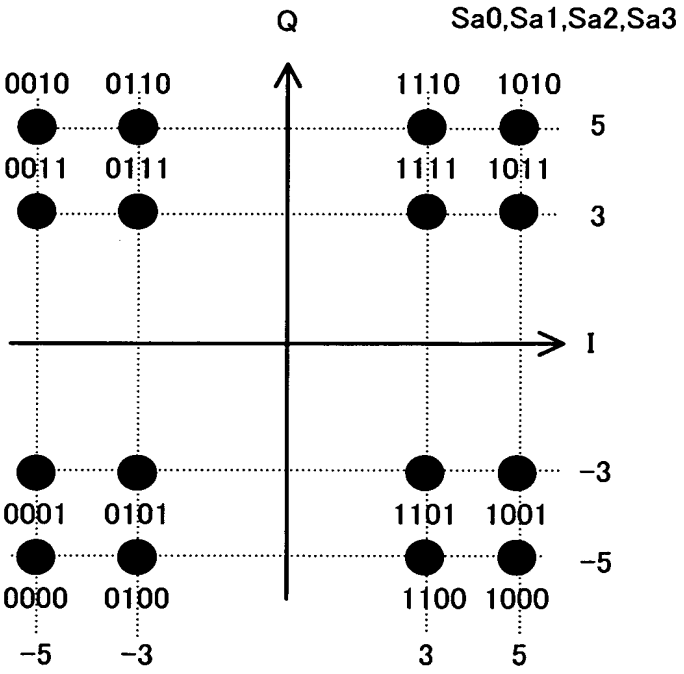


FIG.15A

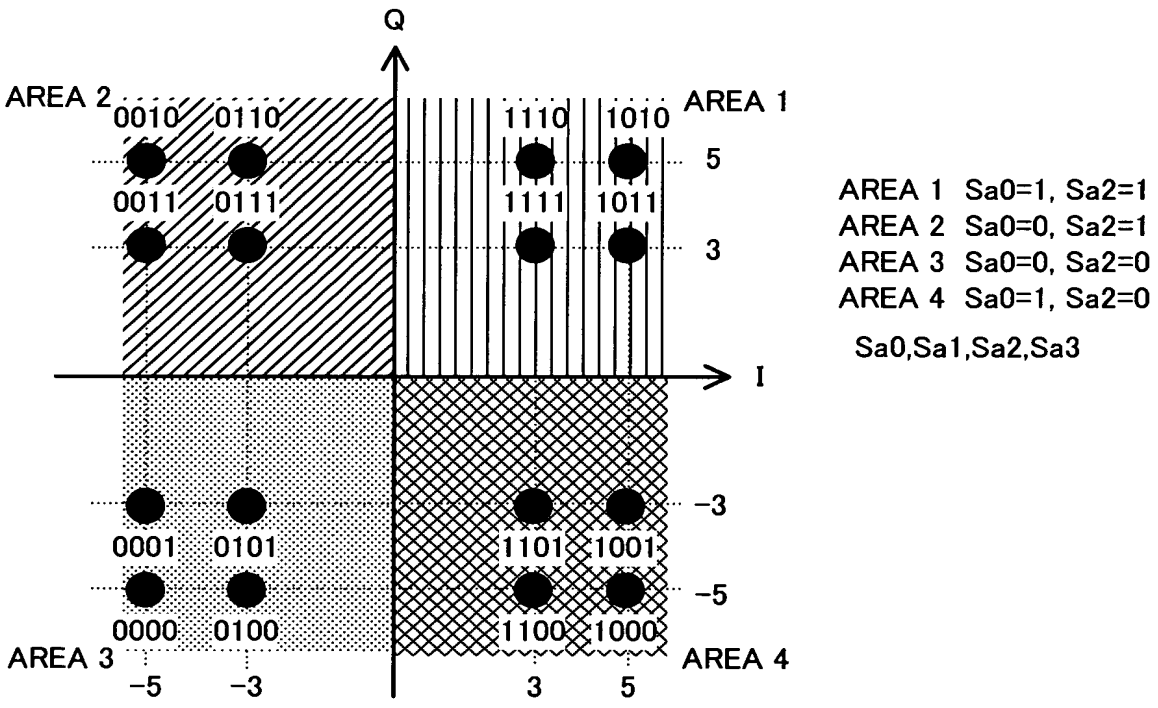


FIG.15B

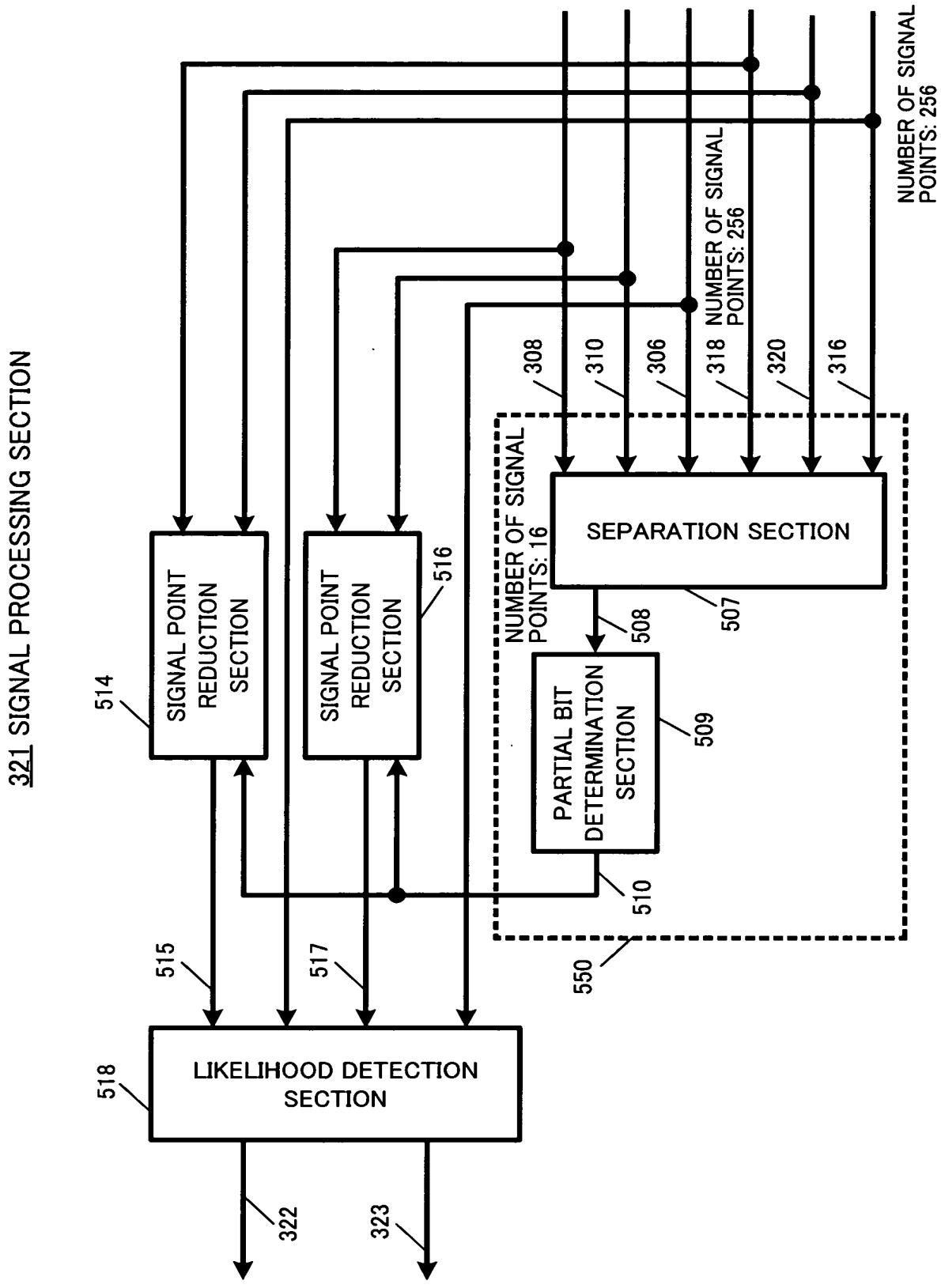

321 SIGNAL PROCESSING SECTION
NUMBER OF SIGNAL POINTS: 256
NUMBER OF SIGNAL POINTS: 256
308
310
306
318
320
316
NUMBER OF SIGNAL POINTS: 16
SEPARATION SECTION
507
508
PARTIAL BIT DETERMINATION SECTION
509
510
550
514
SIGNAL POINT REDUCTION SECTION
516
SIGNAL POINT REDUCTION SECTION
515
517
518
LIKELIHOOD DETECTION SECTION
322
323

FIG.16

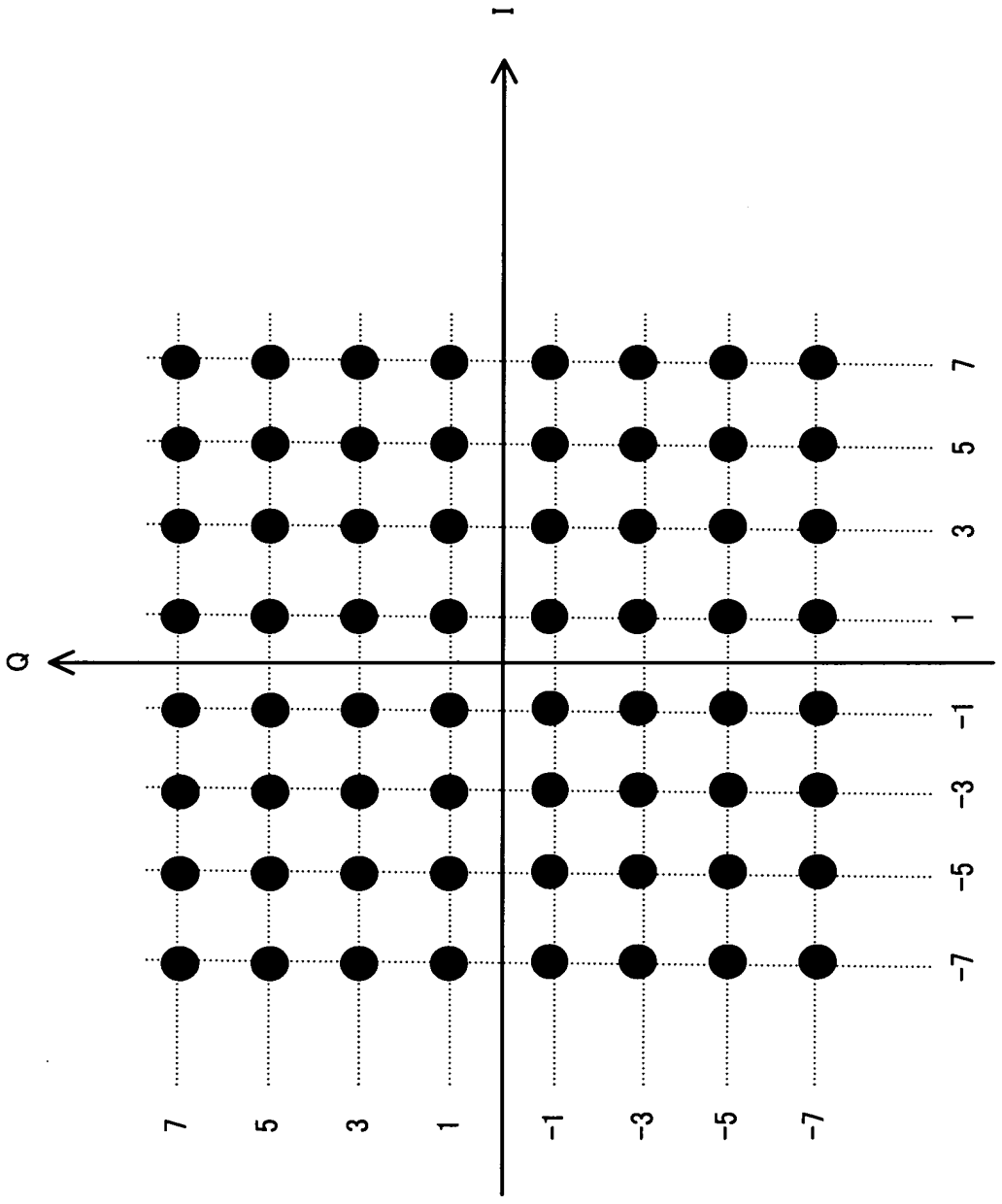


FIG.17

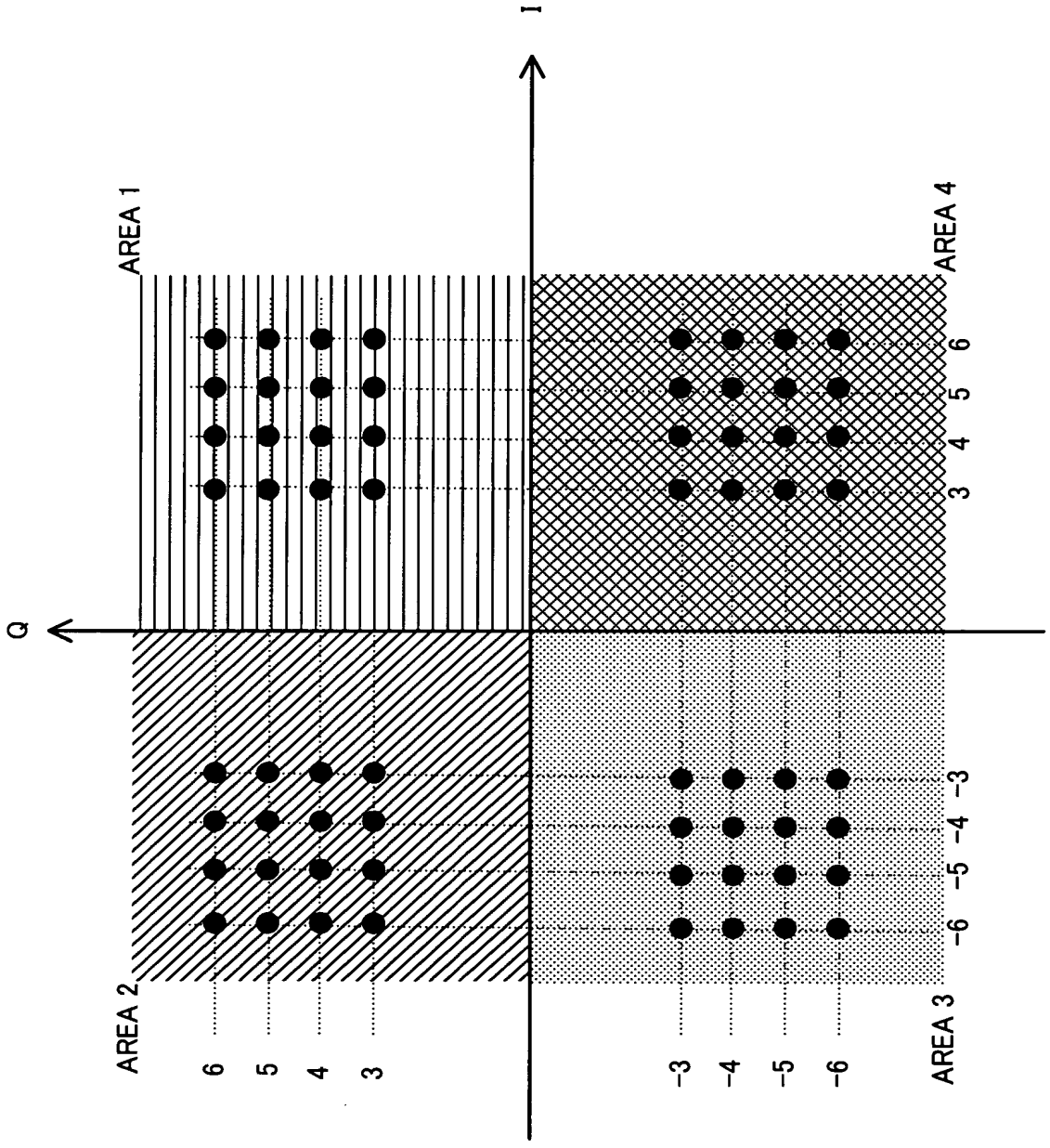


FIG.18

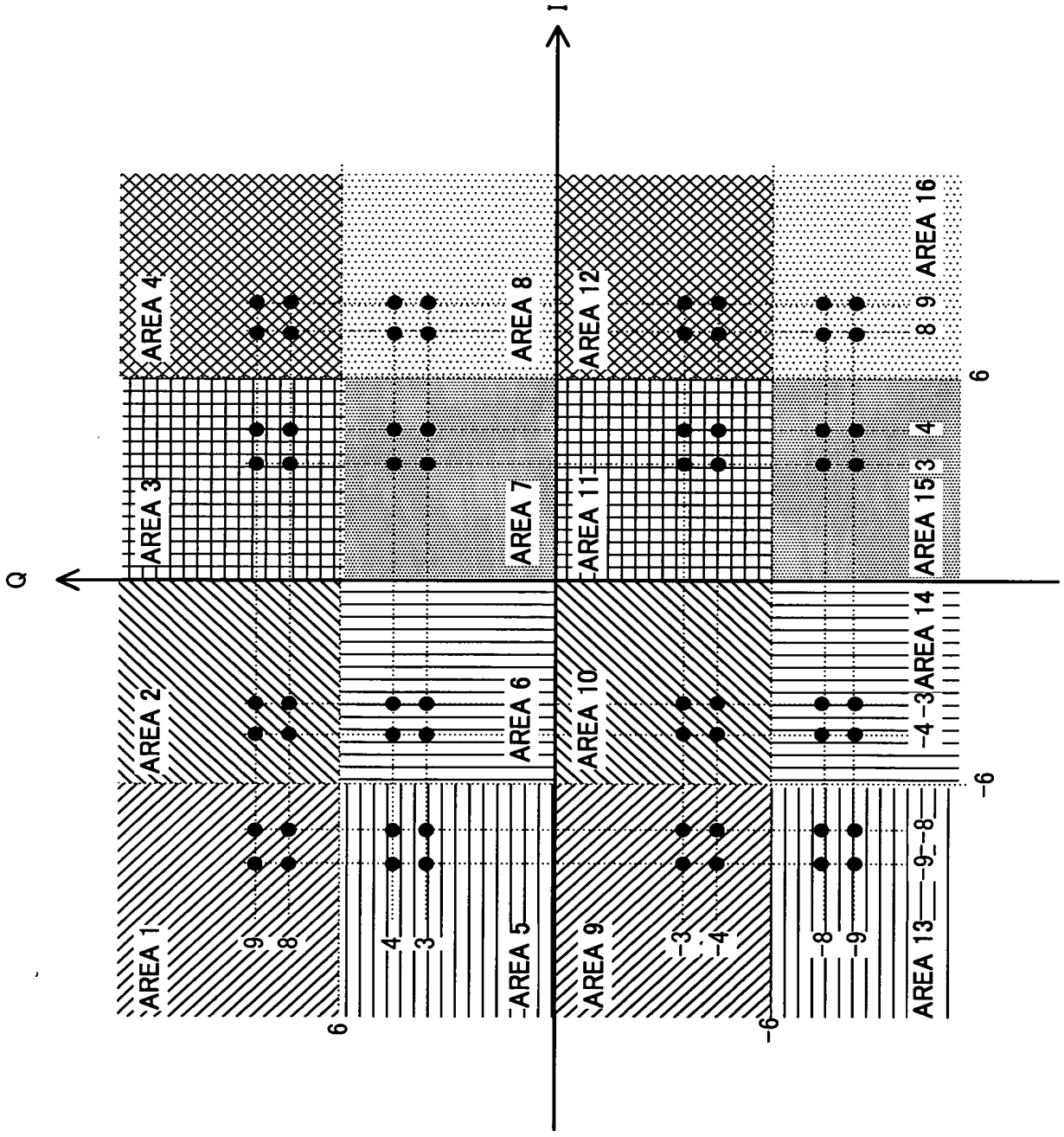

I
Q
AREA 1
AREA 2
AREA 3
AREA 4
AREA 5
AREA 6
AREA 7
AREA 8
AREA 9
AREA 10
AREA 11
AREA 12
AREA 13
AREA 14
AREA 15
AREA 16
9
8
4
3
-4
-3
-9
-8
6
-6

FIG.19

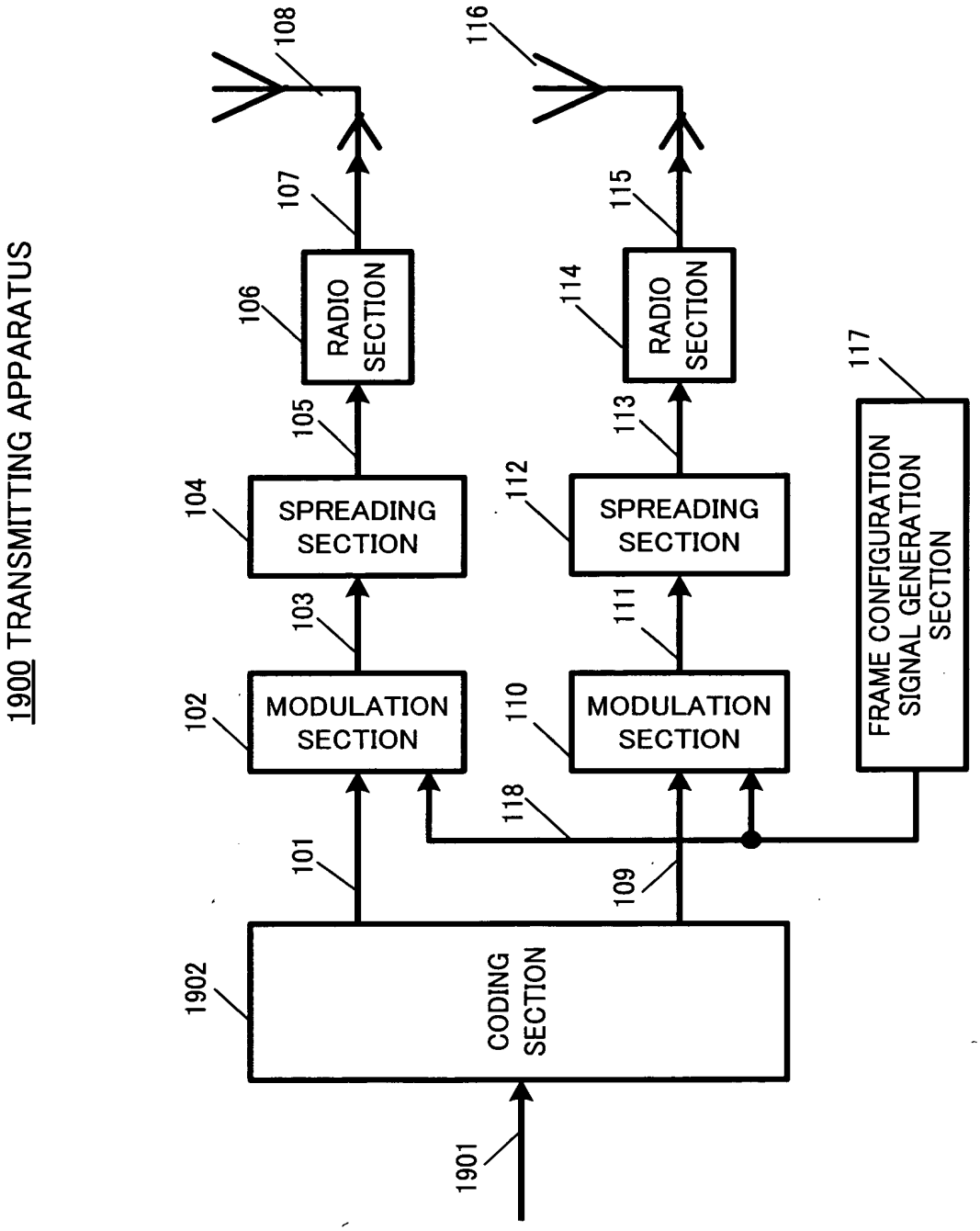

1900 TRANSMITTING APPARATUS
1901
1902
CODING SECTION
101
109
118
102
MODULATION SECTION
110
MODULATION SECTION
103
111
104
SPREADING SECTION
112
SPREADING SECTION
105
113
106
RADIO SECTION
114
RADIO SECTION
107
115
108
116
117
FRAME CONFIGURATION SIGNAL GENERATION SECTION

FIG.20

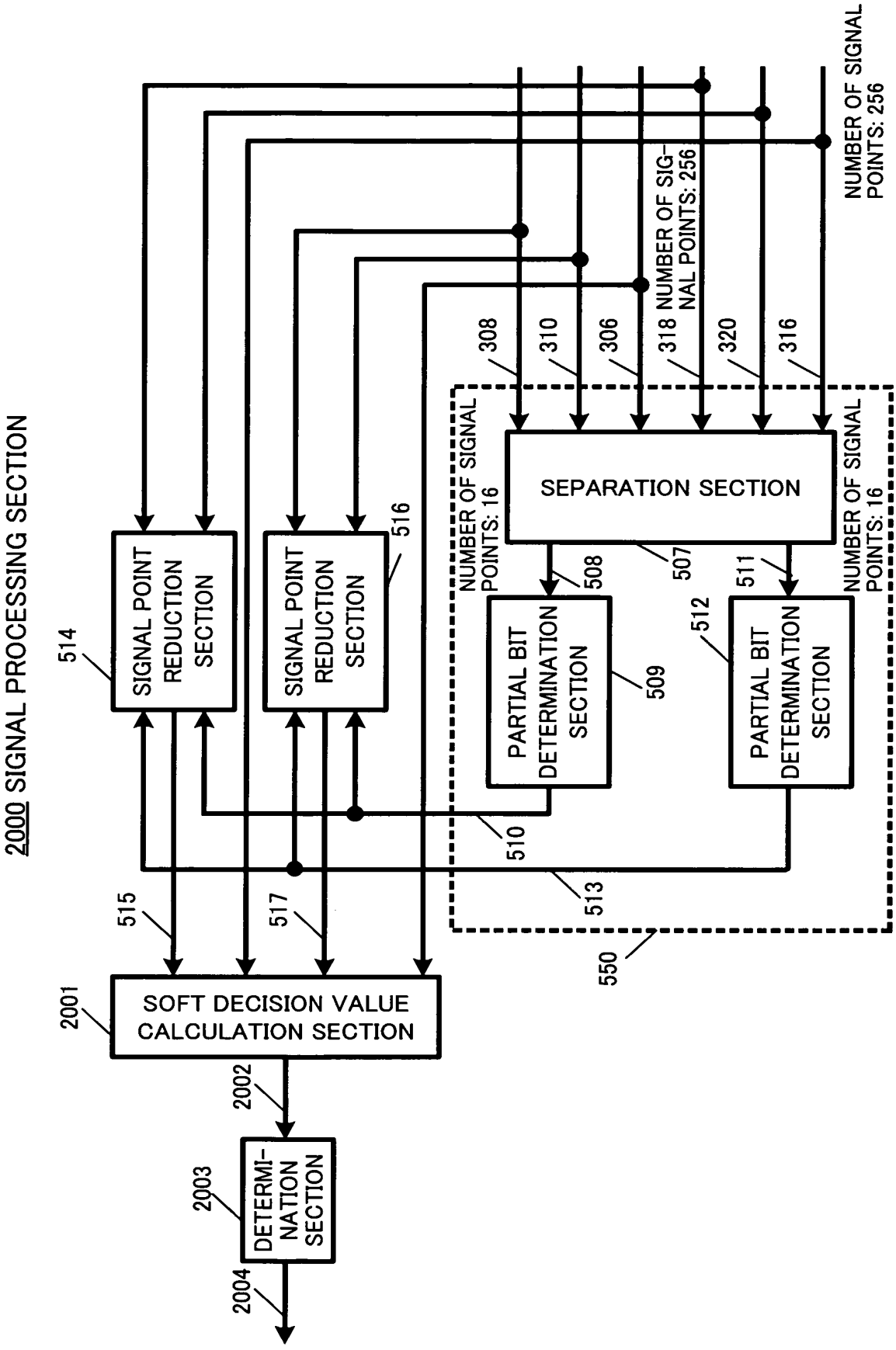

2000 SIGNAL PROCESSING SECTION
NUMBER OF SIGNAL POINTS: 256
NUMBER OF SIGNAL POINTS: 256
308
310
306
318
320
316
SEPARATION SECTION
NUMBER OF SIGNAL POINTS: 16
NUMBER OF SIGNAL POINTS: 16
507
508
511
512
PARTIAL BIT DETERMINATION SECTION
509
PARTIAL BIT DETERMINATION SECTION
510
513
550
514
SIGNAL POINT REDUCTION SECTION
516
SIGNAL POINT REDUCTION SECTION
515
517
2001
SOFT DECISION VALUE CALCULATION SECTION
2002
2003
DETERMI-NATION SECTION
2004

FIG.21

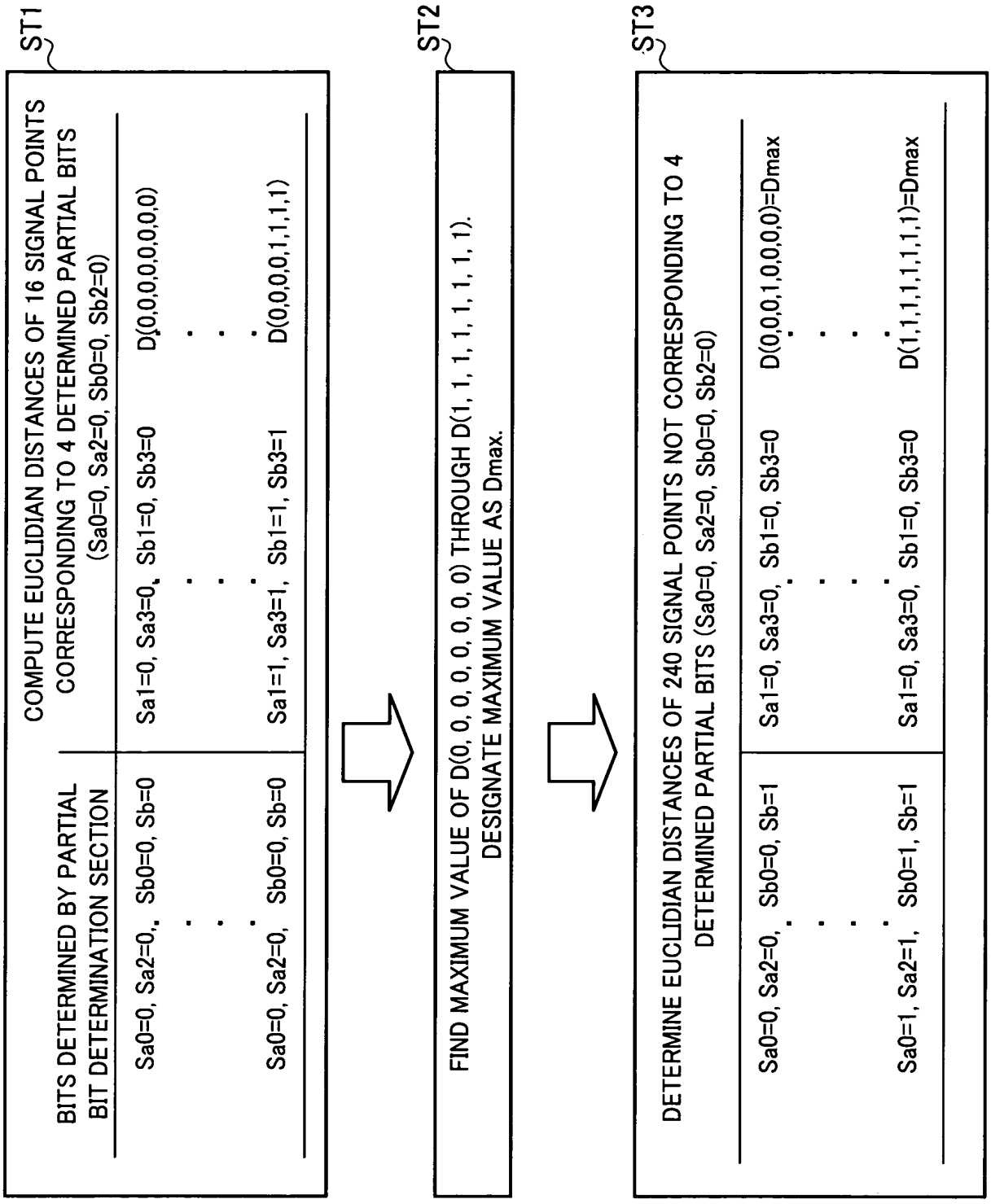

ST1
COMPUTE EUCLIDIAN DISTANCES OF 16 SIGNAL POINTS CORRESPONDING TO 4 DETERMINED PARTIAL BITS (Sa0=0, Sa2=0, Sb0=0, Sb2=0)
BITS DETERMINED BY PARTIAL BIT DETERMINATION SECTION
Sa0=0, Sa2=0, Sb0=0, Sb=0
Sa0=0, Sa2=0, Sb0=0, Sb=0
Sa1=0, Sa3=0, Sb1=0, Sb3=0
D(0,0,0,0,0,0,0,0)
Sa1=1, Sa3=1, Sb1=1, Sb3=1
D(0,0,0,0,1,1,1,1)
ST2
FIND MAXIMUM VALUE OF D(0, 0, 0, 0, 0, 0, 0, 0) THROUGH D(1, 1, 1, 1, 1, 1, 1, 1).
DESIGNATE MAXIMUM VALUE AS Dmax.
ST3
DETERMINE EUCLIDIAN DISTANCES OF 240 SIGNAL POINTS NOT CORRESPONDING TO 4 DETERMINED PARTIAL BITS (Sa0=0, Sa2=0, Sb0=0, Sb2=0)
Sa0=0, Sa2=0, Sb0=0, Sb=1
Sa0=1, Sa2=1, Sb0=1, Sb=1
Sa1=0, Sa3=0, Sb1=0, Sb3=0
D(0,0,0,1,0,0,0,0)=Dmax
Sa1=0, Sa3=0, Sb1=0, Sb3=0
D(1,1,1,1,1,1,1,1)=Dmax

FIG.22

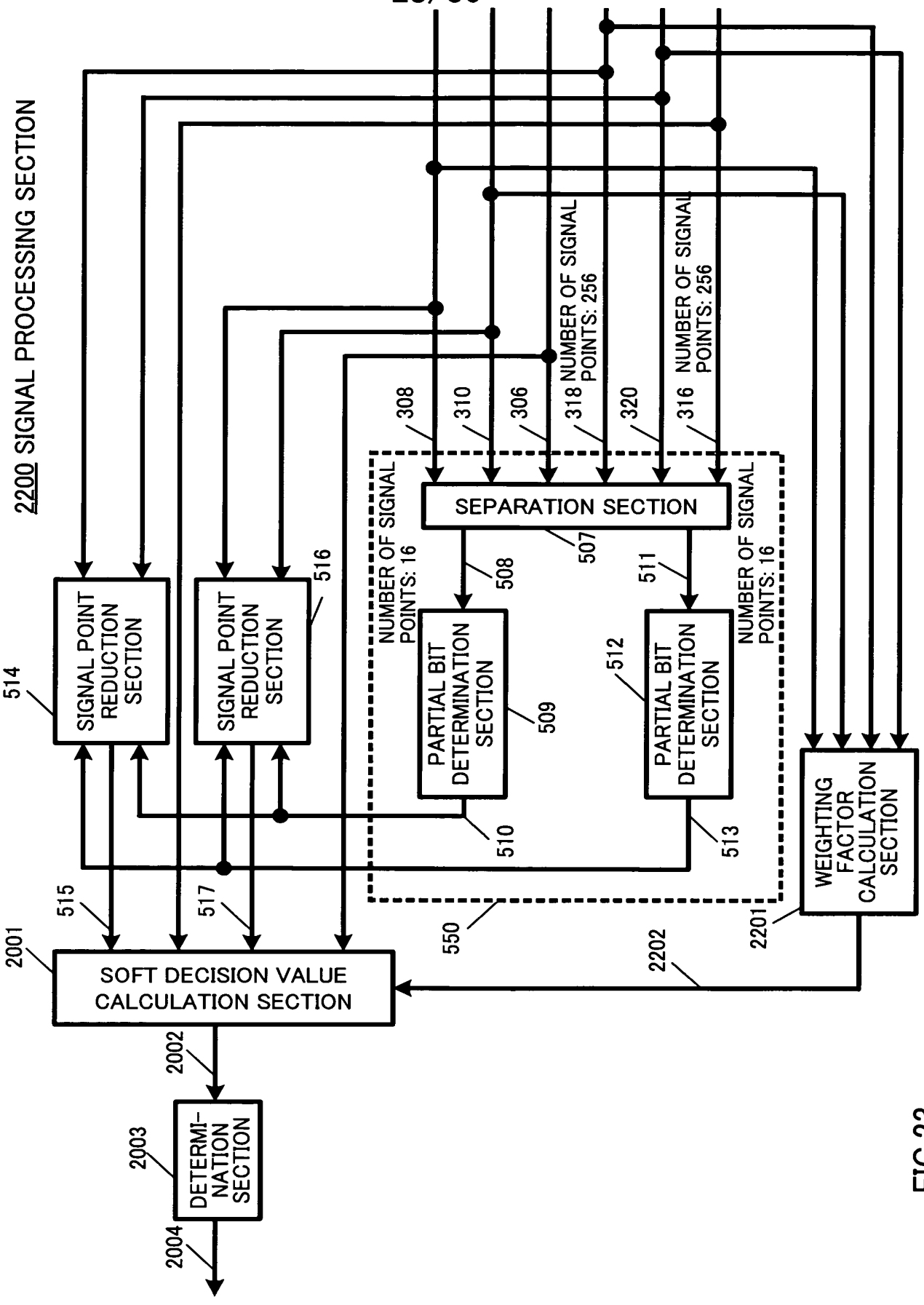

2200 SIGNAL PROCESSING SECTION
SIGNAL POINT REDUCTION SECTION
SIGNAL POINT REDUCTION SECTION
514
516
SEPARATION SECTION
507
NUMBER OF SIGNAL POINTS: 16
NUMBER OF SIGNAL POINTS: 16
308
310
306
318 NUMBER OF SIGNAL POINTS: 256
320
316 NUMBER OF SIGNAL POINTS: 256
508
511
PARTIAL BIT DETERMINATION SECTION
509
PARTIAL BIT DETERMINATION SECTION
512
510
513
WEIGHTING FACTOR CALCULATION SECTION
2201
515
517
550
2001
SOFT DECISION VALUE CALCULATION SECTION
2202
2002
DETERMI-NATION SECTION
2003
2004

FIG.23

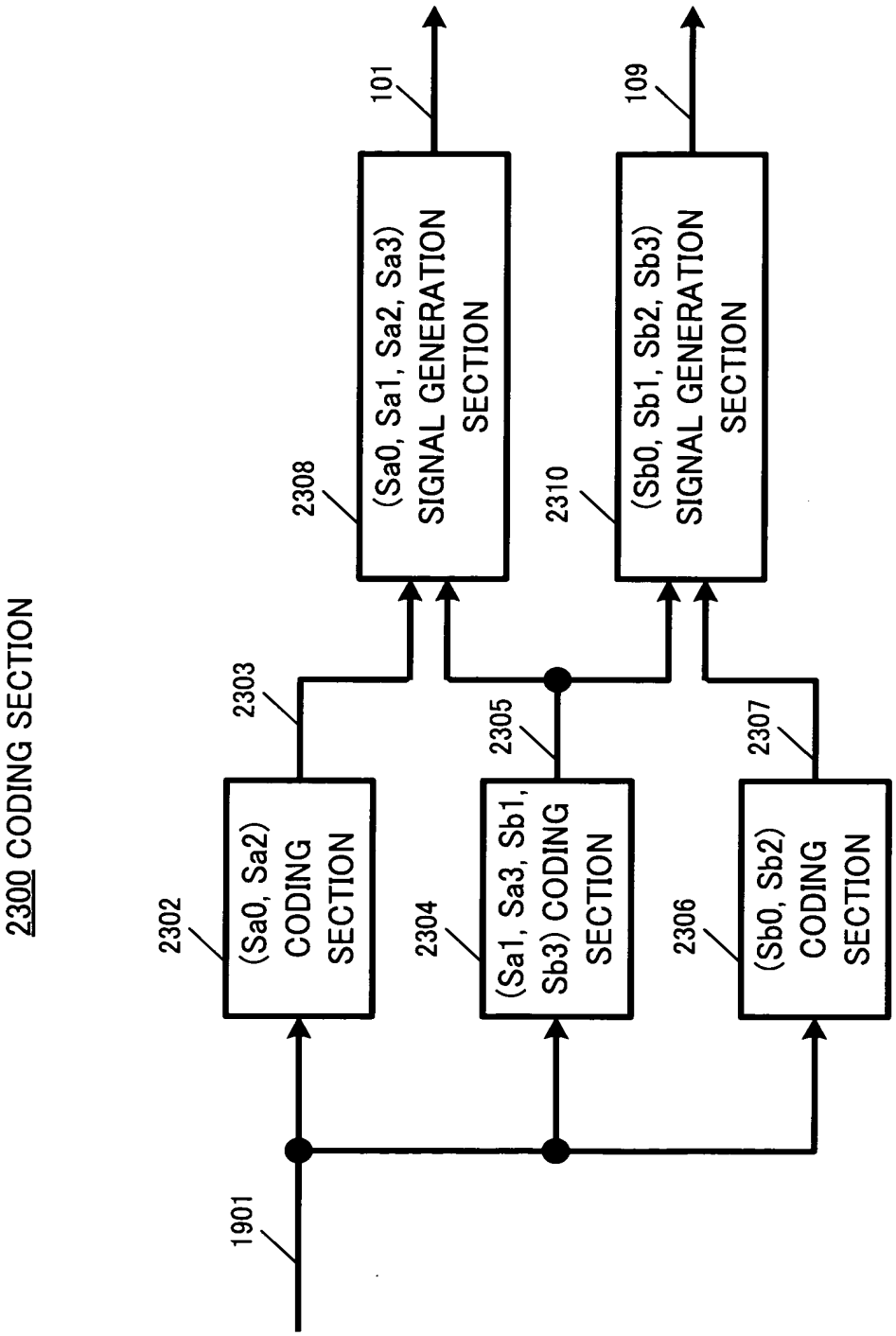

2300 CODING SECTION
1901
2302
(Sa0, Sa2) CODING SECTION
2304
(Sa1, Sa3, Sb1, Sb3) CODING SECTION
2306
(Sb0, Sb2) CODING SECTION
2303
2305
2307
2308
(Sa0, Sa1, Sa2, Sa3) SIGNAL GENERATION SECTION
2310
(Sb0, Sb1, Sb2, Sb3) SIGNAL GENERATION SECTION
101
109

FIG.24

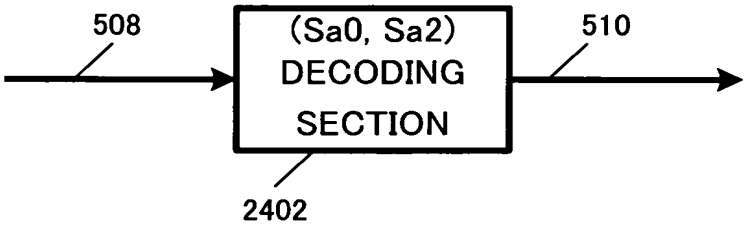


FIG.25A

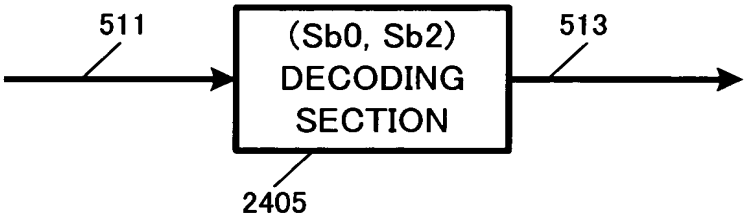


FIG.25B

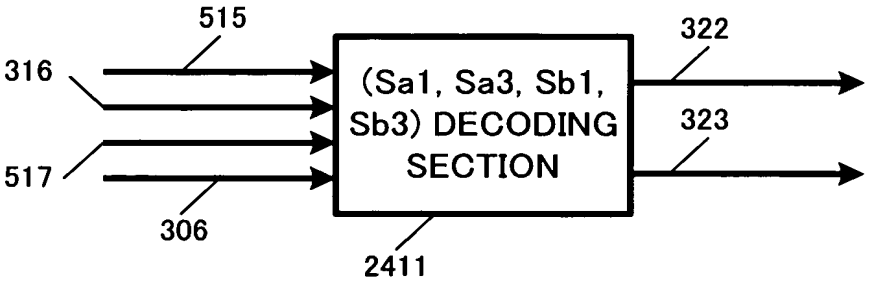


FIG.25C

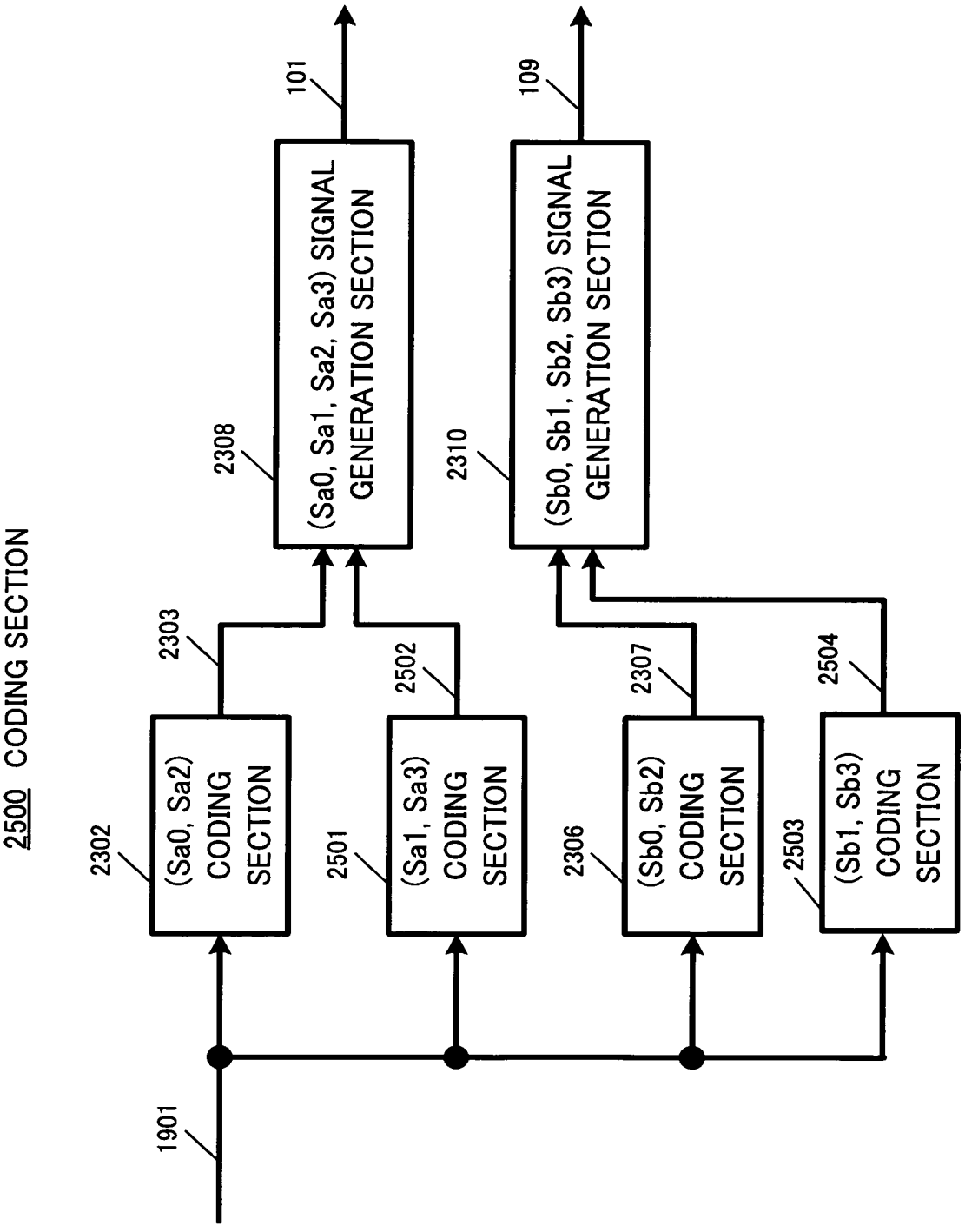

2500 CODING SECTION
1901
2302
(Sa0, Sa2) CODING SECTION
2303
2501
(Sa1, Sa3) CODING SECTION
2502
2306
(Sb0, Sb2) CODING SECTION
2307
2503
(Sb1, Sb3) CODING SECTION
2504
2308
(Sa0, Sa1, Sa2, Sa3) SIGNAL GENERATION SECTION
101
2310
(Sb0, Sb1, Sb2, Sb3) SIGNAL GENERATION SECTION
109

FIG.26

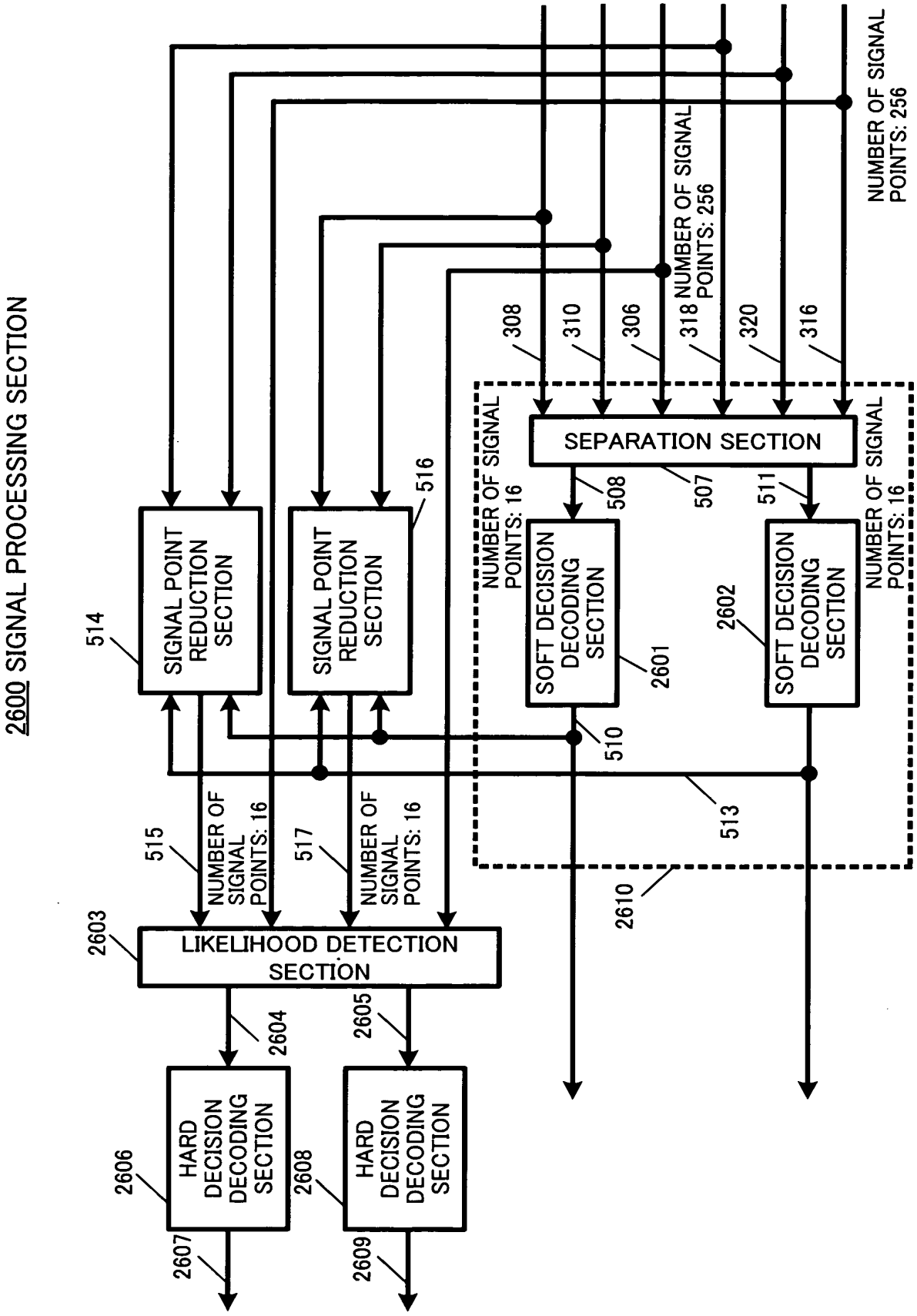

2600 SIGNAL PROCESSING SECTION
NUMBER OF SIGNAL POINTS: 256
308
310
306
318
NUMBER OF SIGNAL POINTS: 256
320
316
SEPARATION SECTION
NUMBER OF SIGNAL POINTS: 16
508
507
511
NUMBER OF SIGNAL POINTS: 16
516
SIGNAL POINT REDUCTION SECTION
SIGNAL POINT REDUCTION SECTION
514
SOFT DECISION DECODING SECTION
2601
SOFT DECISION DECODING SECTION
2602
510
513
515
NUMBER OF SIGNAL POINTS: 16
517
NUMBER OF SIGNAL POINTS: 16
2610
2603
LIKELIHOOD DETECTION SECTION
2604
2605
HARD DECISION DECODING SECTION
2606
HARD DECISION DECODING SECTION
2608
2607
2609

FIG.27

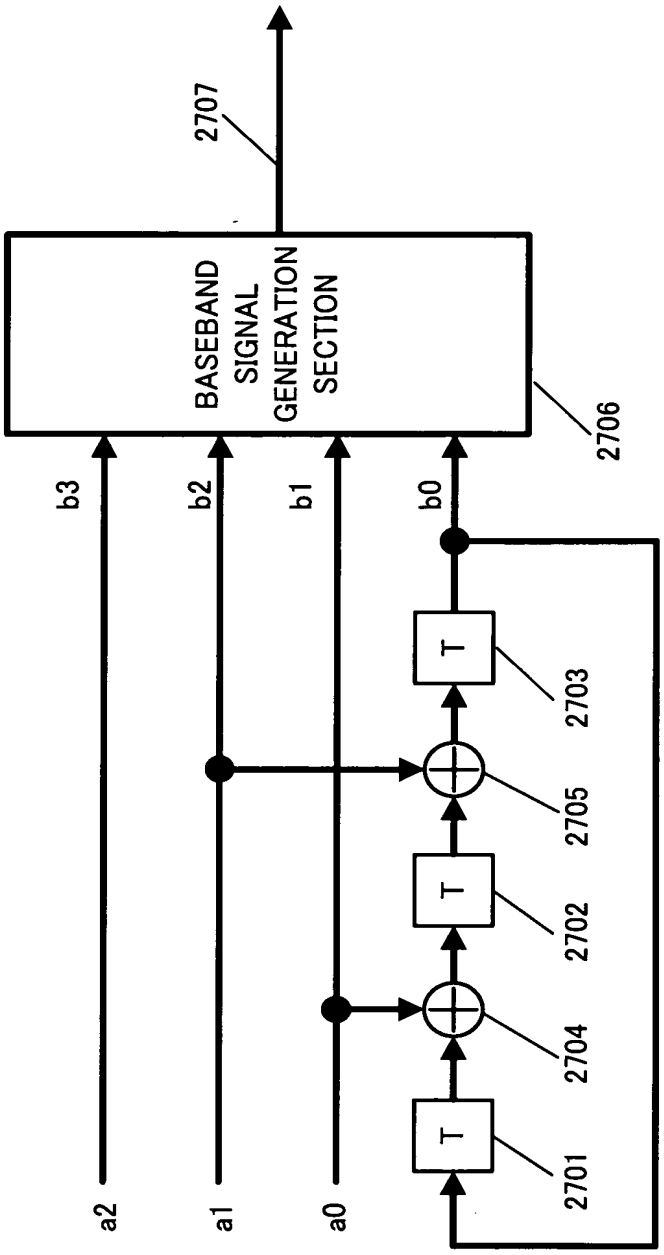

2707
BASEBAND SIGNAL GENERATION SECTION
2706
b3
b2
b1
b0
T
2703
2705
T
2702
2704
T
2701
a2
a1
a0

FIG.28

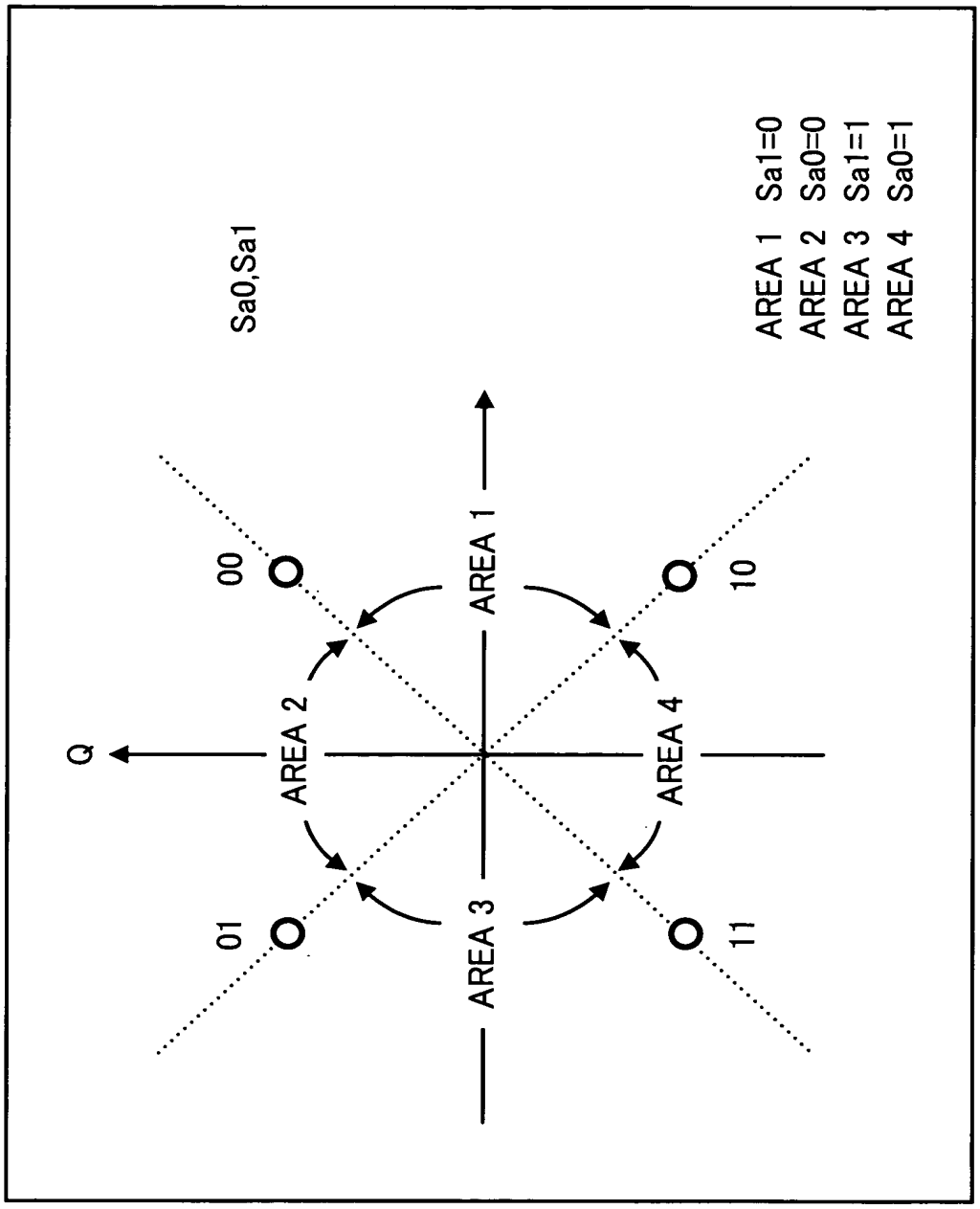

Sa0,Sa1
AREA 1 Sa1=0
AREA 2 Sa0=0
AREA 3 Sa1=1
AREA 4 Sa0=1
00
10
01
11
AREA 1
AREA 2
AREA 3
AREA 4
Q

FIG.29

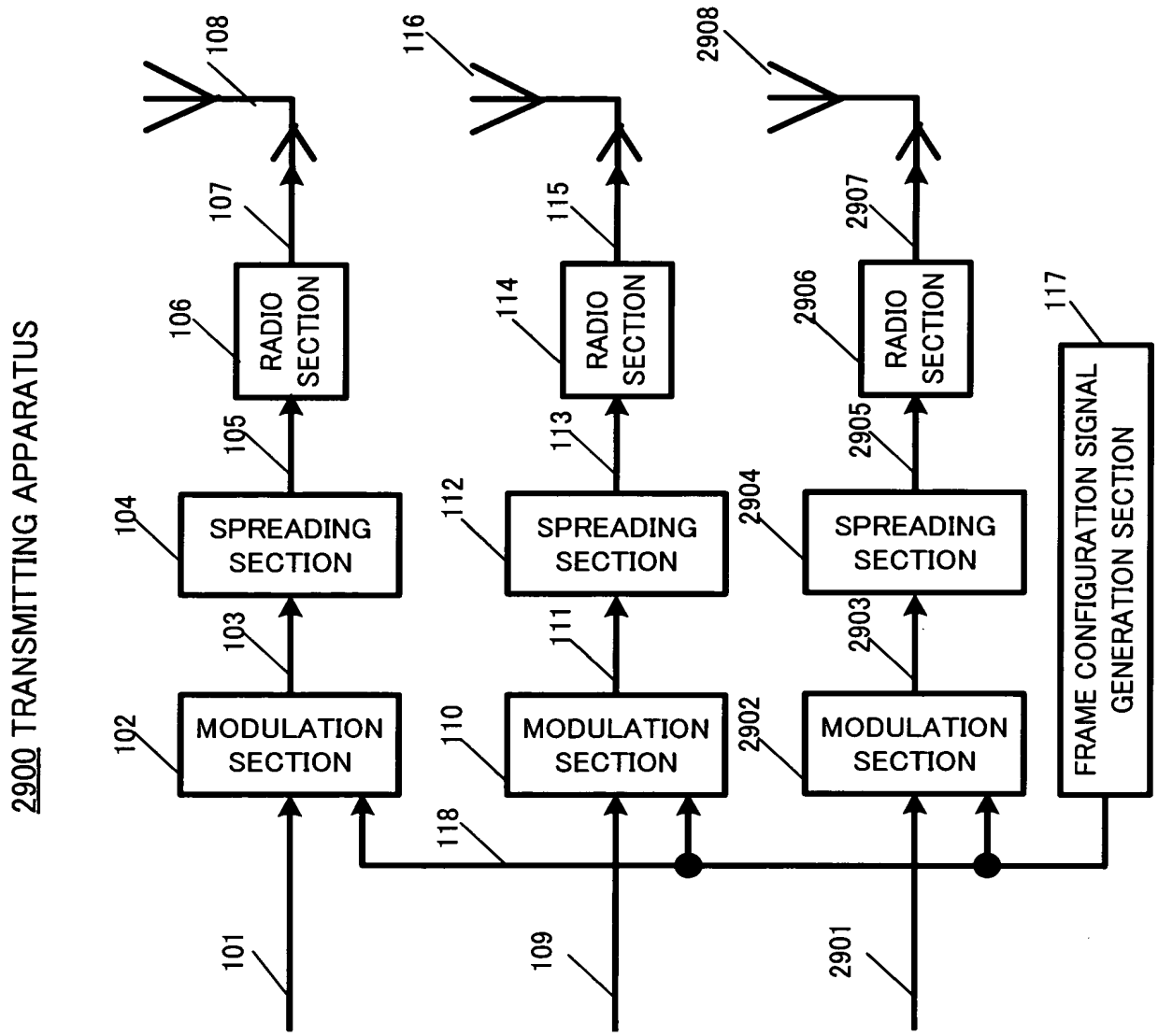

2900 TRANSMITTING APPARATUS
101
102
MODULATION SECTION
103
104
SPREADING SECTION
105
106
RADIO SECTION
107
108
109
110
MODULATION SECTION
111
112
SPREADING SECTION
113
114
RADIO SECTION
115
116
2901
2902
MODULATION SECTION
2903
2904
SPREADING SECTION
2905
2906
RADIO SECTION
2907
2908
117
FRAME CONFIGURATION SIGNAL GENERATION SECTION
118

FIG.30

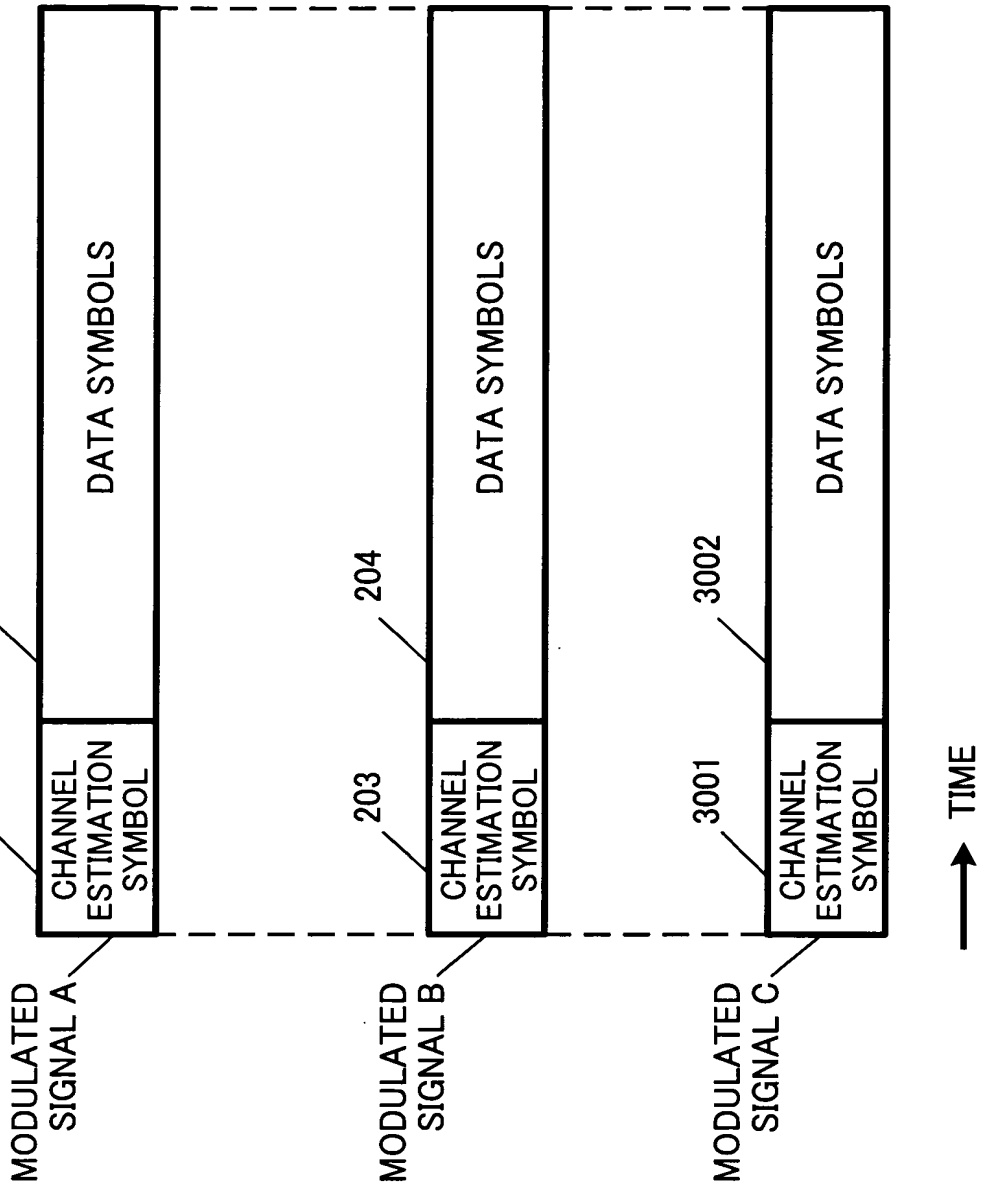

MODULATED SIGNAL A
MODULATED SIGNAL B
MODULATED SIGNAL C
CHANNEL ESTIMATION SYMBOL
DATA SYMBOLS
201
202
203
204
3001
3002
TIME

FIG.31

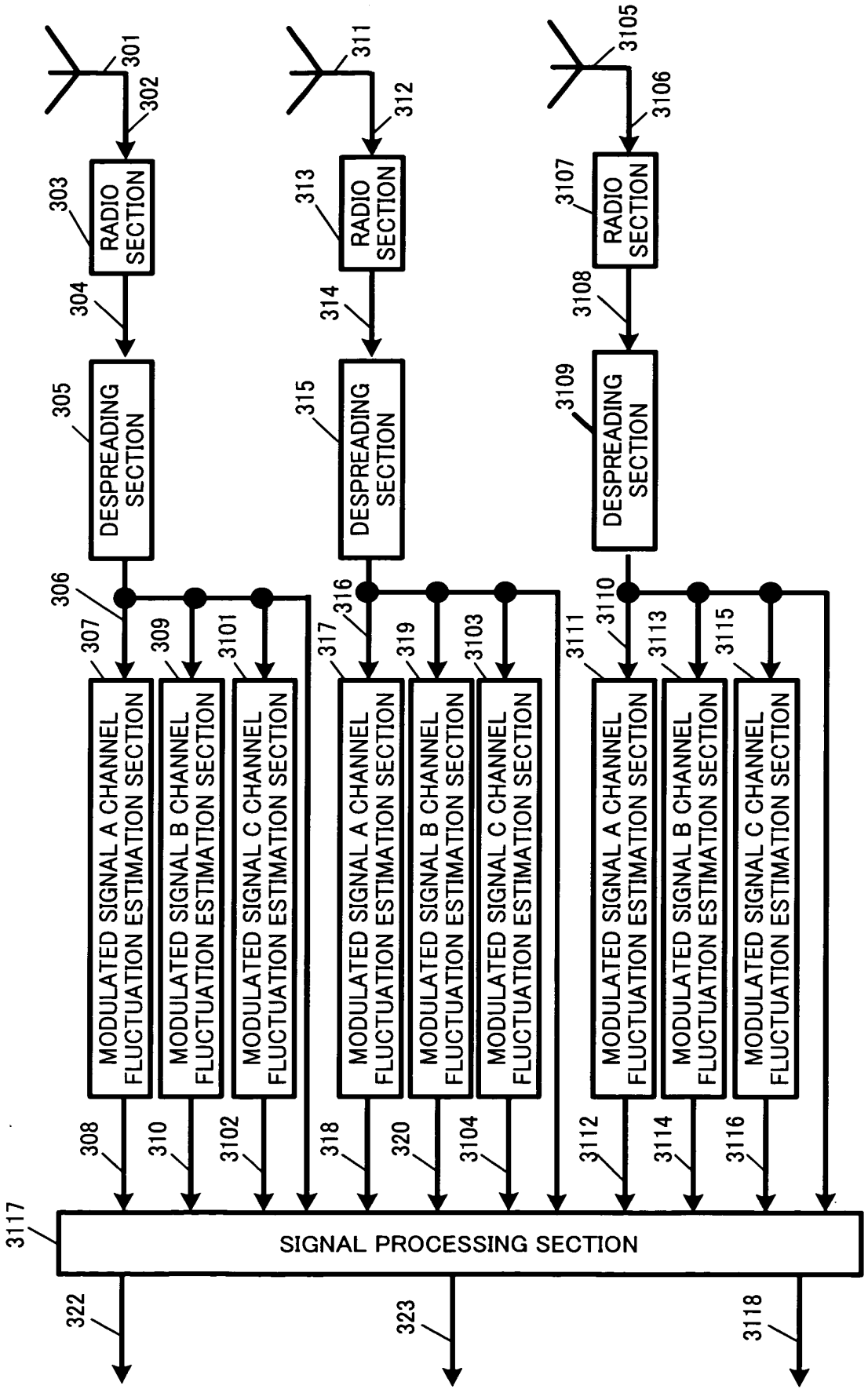

3100 RECEIVING APPARATUS
301
302
303
RADIO SECTION
304
305
DESPREADING SECTION
306
307
309
3101
MODULATED SIGNAL A CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL B CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL C CHANNEL FLUCTUATION ESTIMATION SECTION
308
310
3102
311
312
313
RADIO SECTION
314
315
DESPREADING SECTION
316
317
319
3103
MODULATED SIGNAL A CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL B CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL C CHANNEL FLUCTUATION ESTIMATION SECTION
318
320
3104
3105
3106
3107
RADIO SECTION
3108
3109
DESPREADING SECTION
3110
3111
3113
3115
MODULATED SIGNAL A CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL B CHANNEL FLUCTUATION ESTIMATION SECTION
MODULATED SIGNAL C CHANNEL FLUCTUATION ESTIMATION SECTION
3112
3114
3116
3117
SIGNAL PROCESSING SECTION
322
323
3118

FIG.32

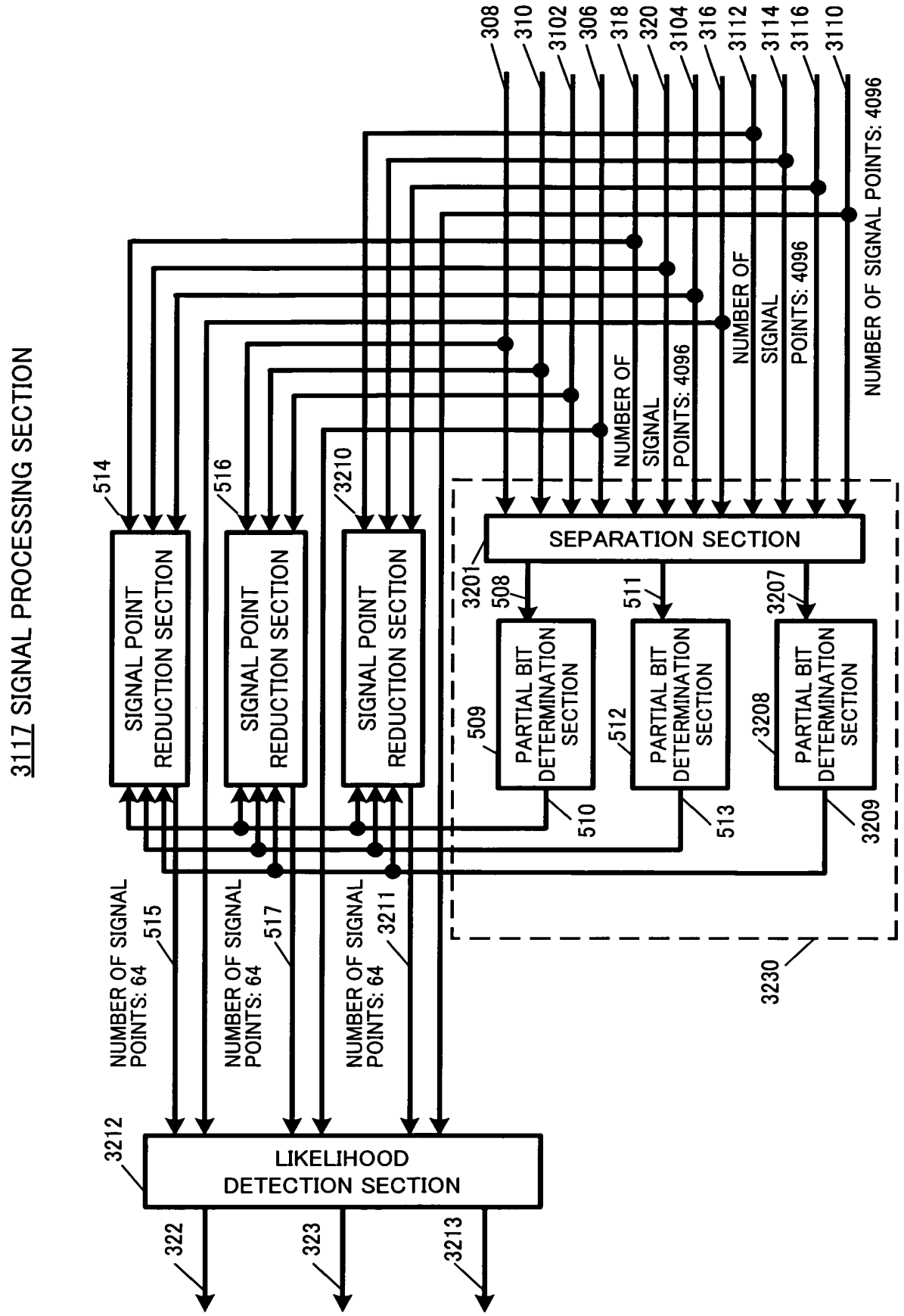

3117 SIGNAL PROCESSING SECTION
308
310
3102
306
318
320
3104
316
3112
3114
3116
3110
NUMBER OF SIGNAL POINTS: 4096
NUMBER OF SIGNAL POINTS: 4096
NUMBER OF SIGNAL POINTS: 4096
514
516
3210
SIGNAL POINT REDUCTION SECTION
SIGNAL POINT REDUCTION SECTION
SIGNAL POINT REDUCTION SECTION
SEPARATION SECTION
3201
508
511
3207
509
512
3208
PARTIAL BIT DETERMINATION SECTION
PARTIAL BIT DETERMINATION SECTION
PARTIAL BIT DETERMINATION SECTION
510
513
3209
3230
NUMBER OF SIGNAL POINTS: 64
NUMBER OF SIGNAL POINTS: 64
NUMBER OF SIGNAL POINTS: 64
515
517
3211
3212
LIKELIHOOD DETECTION SECTION
322
323
3213

FIG.33

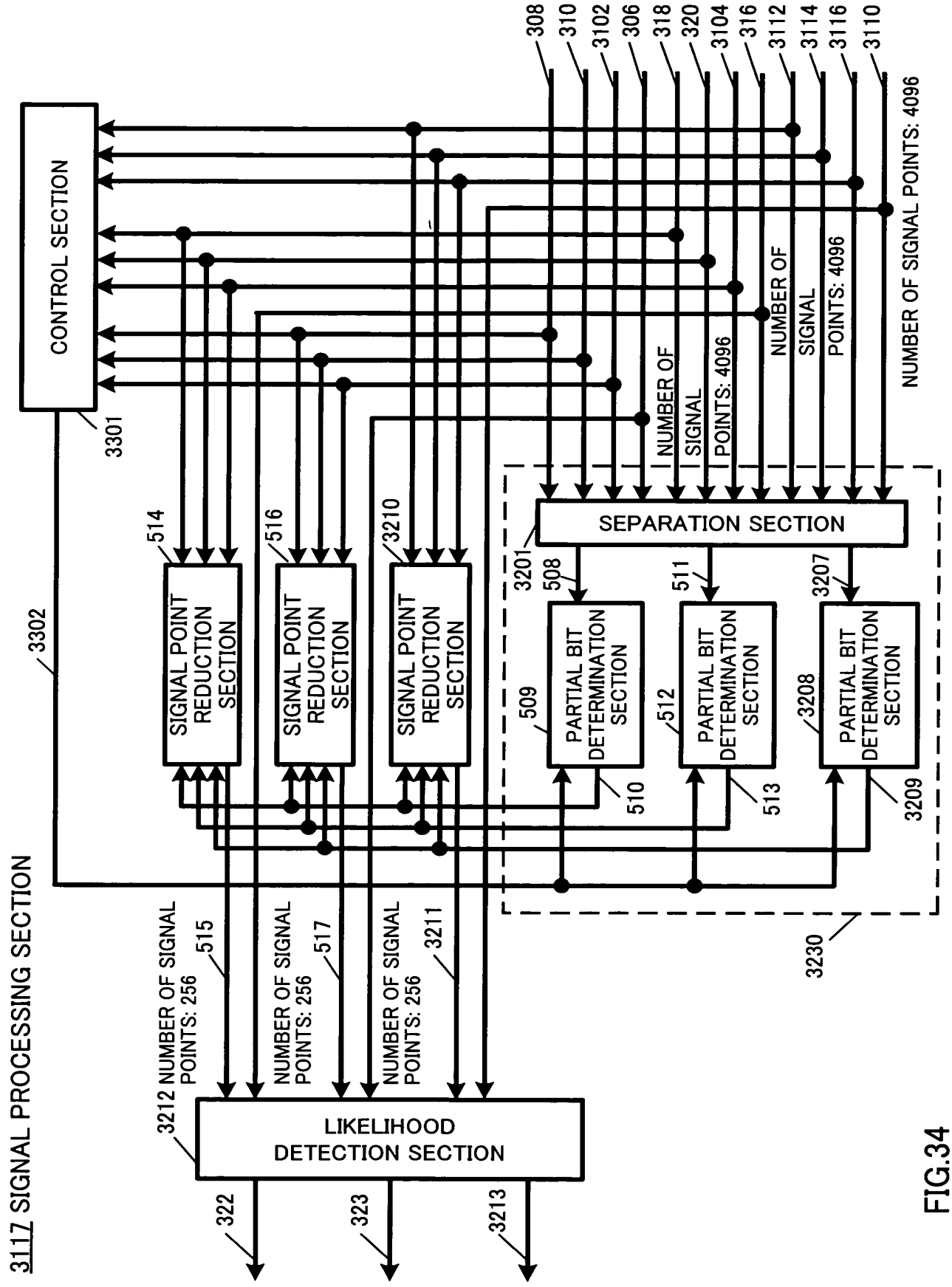

3117 SIGNAL PROCESSING SECTION
CONTROL SECTION
3301
3302
308
310
3102
306
318
320
3104
316
3112
3114
3116
3110
NUMBER OF SIGNAL POINTS: 4096
NUMBER OF SIGNAL POINTS: 4096
NUMBER OF SIGNAL POINTS: 4096
514
516
3210
SIGNAL POINT REDUCTION SECTION
SIGNAL POINT REDUCTION SECTION
SIGNAL POINT REDUCTION SECTION
SEPARATION SECTION
3201
508
511
3207
509
512
3208
PARTIAL BIT DETERMINATION SECTION
PARTIAL BIT DETERMINATION SECTION
PARTIAL BIT DETERMINATION SECTION
510
513
3209
3230
3212 NUMBER OF SIGNAL POINTS: 256
515
NUMBER OF SIGNAL POINTS: 256
517
NUMBER OF SIGNAL POINTS: 256
3211
LIKELIHOOD DETECTION SECTION
322
323
3213

FIG.34

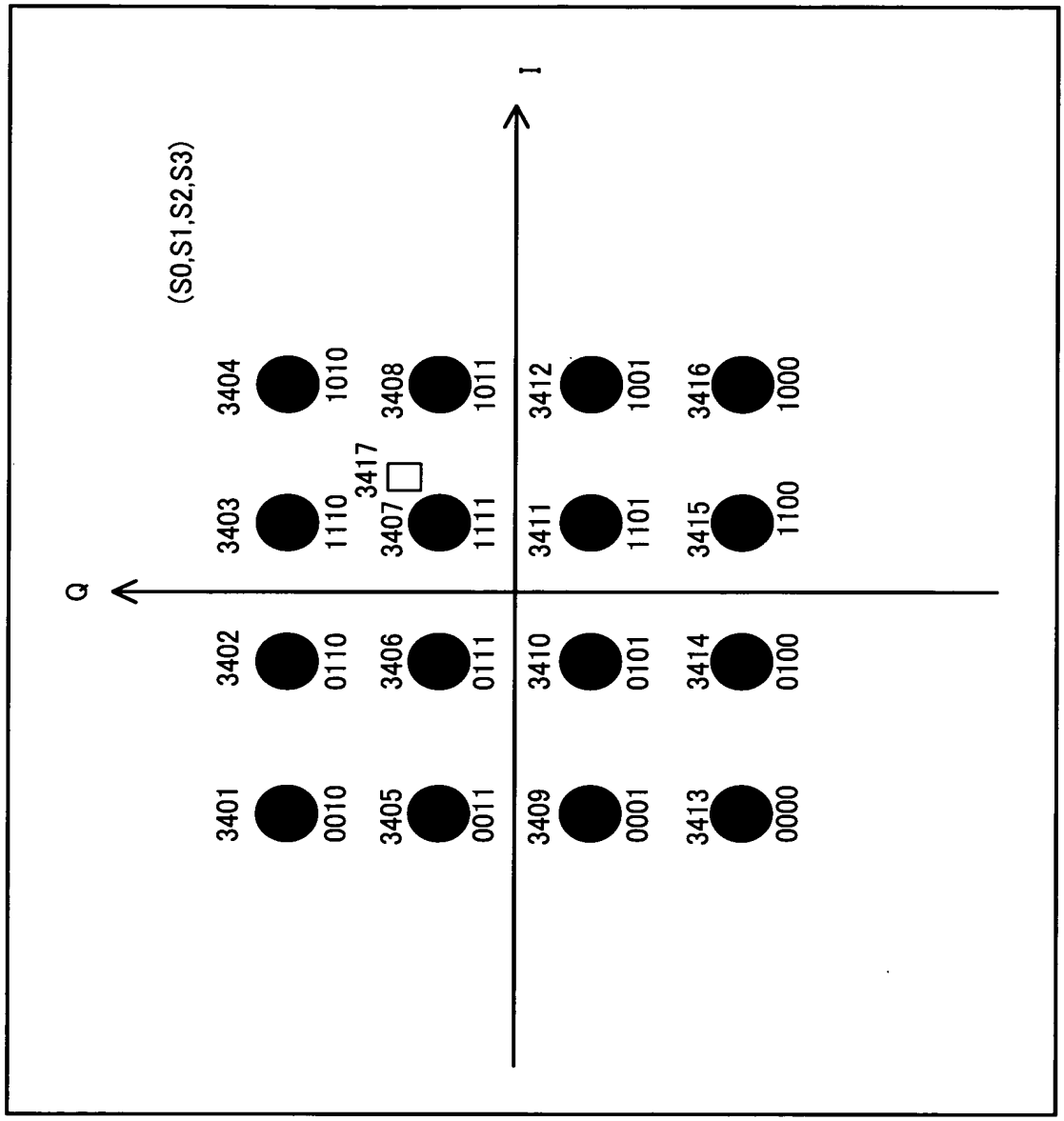

(S0,S1,S2,S3)
I
Q
3401 0010
3402 0110
3403 1110
3404 1010
3405 0011
3406 0111
3407 1111
3408 1011
3409 0001
3410 0101
3411 1101
3412 1001
3413 0000
3414 0100
3415 1100
3416 1000
3417

FIG.35

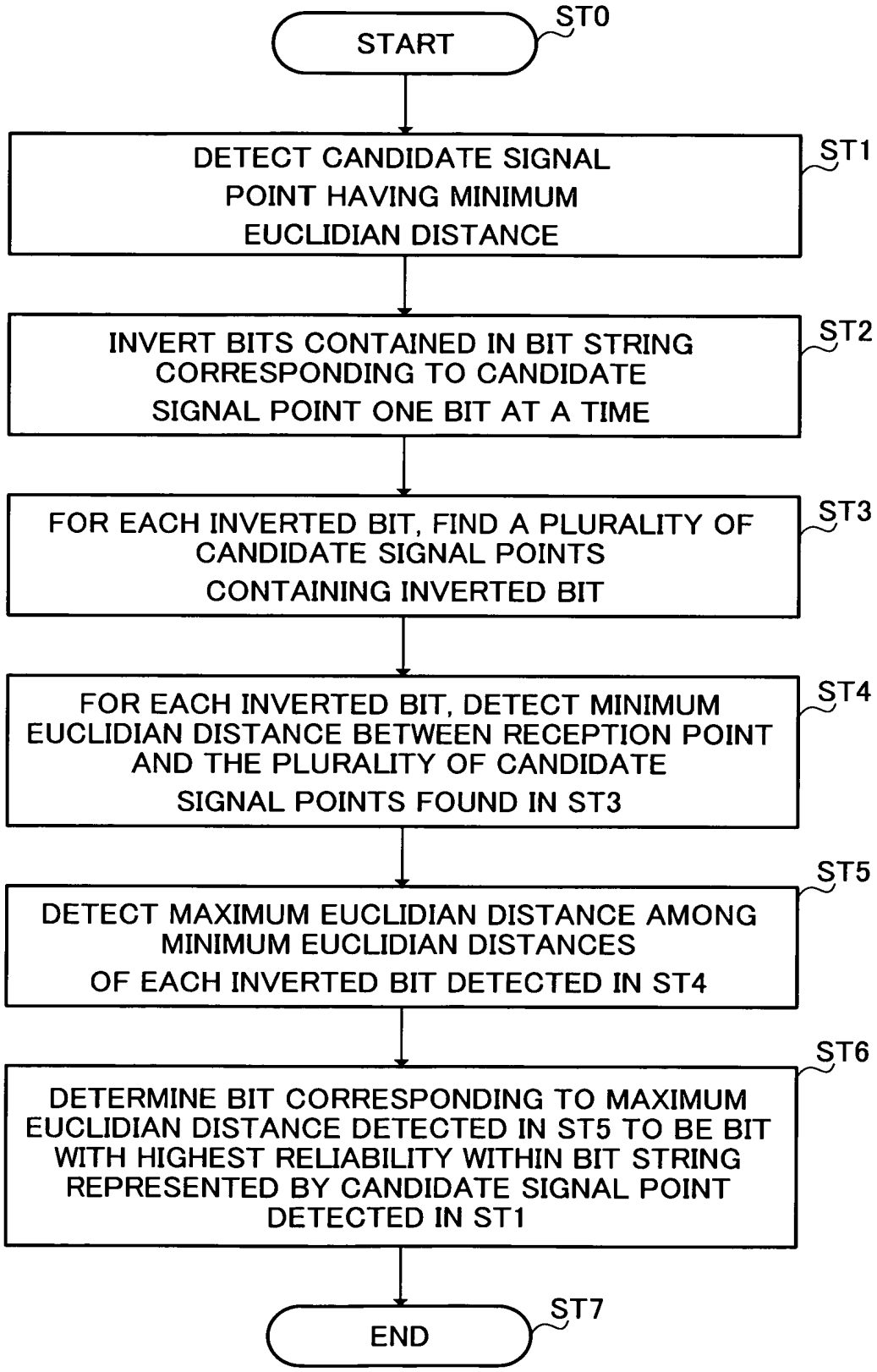

START
ST0
DETECT CANDIDATE SIGNAL POINT HAVING MINIMUM EUCLIDIAN DISTANCE
ST1
INVERT BITS CONTAINED IN BIT STRING CORRESPONDING TO CANDIDATE SIGNAL POINT ONE BIT AT A TIME
ST2
FOR EACH INVERTED BIT, FIND A PLURALITY OF CANDIDATE SIGNAL POINTS CONTAINING INVERTED BIT
ST3
FOR EACH INVERTED BIT, DETECT MINIMUM EUCLIDIAN DISTANCE BETWEEN RECEPTION POINT AND THE PLURALITY OF CANDIDATE SIGNAL POINTS FOUND IN ST3
ST4
DETECT MAXIMUM EUCLIDIAN DISTANCE AMONG MINIMUM EUCLIDIAN DISTANCES OF EACH INVERTED BIT DETECTED IN ST4
ST5
DETERMINE BIT CORRESPONDING TO MAXIMUM EUCLIDIAN DISTANCE DETECTED IN ST5 TO BE BIT WITH HIGHEST RELIABILITY WITHIN BIT STRING REPRESENTED BY CANDIDATE SIGNAL POINT DETECTED IN ST1
ST6
END
ST7

FIG.36